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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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A Heritage of Errors

It is not difficult to discover in almost any technical book a number of trite sayings which have somehow managed to survive from a period when our ideas on the particular subject discussed were very much more vague and superficial than they are to-day. Metallurgical text-books probably suffer from this complaint no more than any other class of work, but when written by engineers on subjects concerning the use of metals as engineering materials it sometimes appears that any amount of this regrettable perpetuation of ancient fallacies is allowed to go unchallenged. Pseudo-scientific generalisations and mysterious and misleading tables of properties, handed down from generation to generation of text-book writers, are religiously copied out with no thought of revision in the light of modern views or practice. In the field of cast-iron metallurgy, for instance, we are almost resigned to the sight of absurdly low figures for tensile and transverse strength, published with every indication of authority, but now, of course, as obsolete as the stage coach. Again, Ewing and Rosenhain laid the ghost of "crystalline metal" as the cause of fatigue failure as long ago as 1899, but it is only recently that this hoary illusion has been finally eradicated from the text-books, and it still crops up occasionally in less-enlightened engineering circles. If there is one other feature which is almost certain to cause engineering authors to fall from grace it is the Izod impact test. Time after time we are solemnly and judicially informed that Izod impact results must not be compared from one material to another—a time-worn cliché which obviously applies to any and every property of a material when isolated from its environment.

It seems that the engineer's mind is constitutionally unable to see with the eye of imagination—to regard his materials from within as delicately balanced forms of matter whose mechanical properties are dependent upon metallographic structure. In no other way can we account for the oft-repeated phrases that for such-and-such a purpose both toughness and ductility are required, or that a certain material was strong enough but failed in fatigue. The fault presumably lies in the insufferable dreariness and mediocrity of the literature on materials upon which engineering students are nurtured. Those sketchy chapters on materials which are included in all books on machine design, for example, generally constitute hot-beds of error and half-truths. To-day, when engineering progress is so much bound up with the application of physico-metallurgical concepts to the study and development of materials, it is more than ever necessary for the engineer to make himself acquainted with modern views on this subject, and thus for authors of engineering texts to make a whole-hearted attempt to deal with the materials side of engineering in a more satisfactory manner. To put about dyspeptic paradoxes with the air of authority is not merely useless; it serves to lower the general level of intelligence.

Standard Symbols

It is occasionally a matter for complaint that some technical and scientific writers use symbols and abbreviated modes of expression without a clear statement, or at any rate a common understanding, of their significance. Thus in Germany conventional symbols for transverse and tensile strength of cast iron are used, and are not accepted or used outside that country, and in England certain usages are common which would give rise to the same criticism. In other cases confusion is caused by having two well-known symbols for one thing, and those who have become accustomed to one find it difficult to read Papers using the other. In the United States there is a typewriter symbol used for lbs. or lbs. per sq. in. which is very unfamiliar to outsiders, and so on.

The British Standards Institution has taken a commendable step in issuing a publication on British Standard Engineering Symbols and Abbreviations, and several symbols of interest to founders are proposed. Incidentally, although prepared, issued, numbered and indexed as a British Standard Specification, this publication is actually not a specification. It is, nevertheless, of great value and should be adopted by all designers, draughtsmen, engineers and writers of Papers and technical books, as well as the earlier one on drawing-office practice. The principle adopted has been to use, as far as possible, one abbreviation only for each term, and where usage justifies two, to prefer one; to discourage the use of capital letters, and to discard the plural form. The list covers primary units of length, area, volume, weight, and signs used in mathematics and physics, as well as general engineering terms.

For materials, cast iron becomes C.I.; malleable cast iron is M.C.I.; and soft cast iron is S.C.I. Then cast steel becomes C.S.; aluminium Al., and so on. Other abbreviations cover heat-treatment; thus "annealed" is covered by "ann." When it is pointed out that this report contains over sixty pages, it will be seen that a vast field has been covered, and secretaries of scientific and technical institutions and research associations should insist on all their authors using these standard abbreviations, with an intimation that any departures will be corrected in manuscript or in proof. Papers could be marked: Symbols and Abbreviations as per B.S.S 560—1934.

XUM

International Foundry Congress

THE RETURN VOYAGE

FROM OUR SPECIAL CORRESPONDENT.

As previously reported, the British, Belgian and French delegates to the Congress left New York on the French liner "Champlain" on Saturday, October 27. Two days later the following radiogram was received from the President of the Institute of British Foundrymen:—

> "Makemson, Champlain, Portishead, G.K.T. Greetings to British Delegation, *bon voyage*, welcome home.—Stubbs."

A suitable reply was immediately despatched to Mr. Stubbs on behalf of the party.

Unlike the outward voyage, the return was made in delightful weather. The sea was calm and there was continuous sunshine.

The Commander of the "Champlain," like his colleague on the "Lafayette," entertained the whole of the foundry congress passengers at a delightful little informal party. A number of us also inspected the engine rooms, boiler house and refrigerating plant, and the kitchens. The "Champlain" is a 28,000-ton boat, twin screw, driven by steam turbines. Steam for the main turbines is supplied from six boilers and there are two boilers for auxiliary steam supply. As on the "Lafayette," we noted that much of the auxiliary is of British manufacture, Weir pumps being fitted, for example.

A very pleasant voyage terminated by our arrival at Plymouth at 2.45 a.m. on Saturday, November 3. Fortunately we were not put ashore until 6.30 a.m. As the tender left the ship and proceeded to Plymouth, the "Champlain" started on the last stage of her voyage to Havre. Some of our Continental colleagues had risen early in order to say *au revoir* to us, and they stood on deck waving their goodbyes as the "Champlain" proceeded to the open sea.

We omitted to mention in our last article that at the opening meeting of the Congress in Philadelphia, cablegrams were received from a number of European foundrymen who were unable to be present. Our American friends were particularly pleased at the receipt of messages from the President of the Institute of British Foundrymen, Mr. Roy Stubbs, and from Mr. John Shaw.

Publication Received

Aluminium in Shipbuilding. Published by The British Aluminium Company, Limited, Adelaide House, King William Street, London, E.C.4.

This symposium typifies the highest form of publicity known to engineering, as, by its presentation, the authoritative opinions it expresses, and the comprehensive nature of the ground it covers, it demands the serious attention of a wide public possessing an extremely high buying capacity. Just one little mistake has been made and that is neither a contents list nor index has been included. Whilst in a book of fifty odd pages it is not an essential, it is at least desirable. The opening article is by Sir Westcott Abel, the eminent designer. This is followed by one from the pen of Mr. A. T. Wall, managing director of J. Samuel White & Company, Limited, who deals with the possible applications of light alloys in the actual construction of cargo vessels. Warships are covered by Mr. E. F. Spanner, who deals with the subject mainly from the angle of the reduction of weight by the use of aluminium internal fittings and engine parts. "The Equipment of Passenger Ships" is the subject of an article by Mr. H. C. Carey; whilst, finally, the fire hazard afloat is intelligently dealt with by Mr. H. A. Lyndsay. We strongly advise every non-ferrous foundry executive to procure a copy of this really interesting brochure.

District Presidents.—No. 10

LONDON BRANCH OF THE INSTITUTE OF METALS

DR. COLIN JAMES SMITHELLS, President of the London Branch of the Institute of Metals, was educated at Bedales School and Leeds University (1910-1914), where he took the B.Sc. (Chemistry) degree with 1st class honours, and in 1922 the doctorate of Science (Leeds). In August, 1914, Dr. Smithells took a commission in the 9th Glo'ster Regt. He remained with this unit throughout the war, serving in France and Salonica. He was promoted major and second in command of the Battalion in 1917, and was mentioned in dispatches (1916) and awarded the

DR. C. J. SMITHELLS.

Military Cross (1917). In March, 1919, he joined the staff of the Research Laboratories then being formed by the General Electric Company, Limited. Dr. Smithells is the author of "Tungsten" and "Impurities in Metals," and numerous Papers in the scientific journals. He has been a member of the Institute of Metals since 1922 and represents the local sections on the Council. In 1918 he married Mary, daughter of Prof. J. B. Cohen, and has four children.

Answer to Foundry Query

UNMACHINABLE IMPELLER CASTING

We have now made an impeller casting in accordance with "Previously Troubled's" kind suggestion and sketch, but we regret to report no improvement. However, neither your good self nor "Previously Troubled" need worry any further in the matter because we have solved the difficulty by annealing the castings after they come from the sand as suggested by "W. R.," and with very satisfactory results. If you think this information will be of any use to your readers, you are quite at liberty to publish it, for we are quite as anxious to give help as to get it.

"PUMP."

Random Shots

Like all good foundrymen, "Marksman" has been obliged to make some study of draughts in relation to the removal of fumes and the firing of furnaces, but the recent cold snap has compelled the consideration of draughts in a somewhat different category. The other night "Marksman," having, so to speak, hewn the wood and drawn the water of his daily toil, was snugly ensconced before the fire with pipe and book (the "fiddlers three" had gone to the pictures), when sakes alive, a draught, cold, merciless and penetrating came sailing into the room. "All windows were shut, fast closed stood the door, yet piercingly cold was the draught on the floor." (All rights reserved.)

* * *

Now "Marksman" is not a foundryman for nothing, and in accordance with the best traditions of the calling it was obviously impossible to take this lying down, for ardour would assuredly have cooled very rapidly in a recumbent position. It was a *very* cold draught; worse than an overdraft, except that it carried no security and was, perhaps, lacking in interest to one who wanted nothing else than warmth and comfort. Reluctantly "Marksman" came to the conclusion that the evening's annealing process must be abandoned, or at any rate suspended, pending exhaustive (and probably exhausting) investigations. For a time, therefore, "Marksman" was compelled to abandon his aim and join the ranks of the draughtsmen. A noble profession when pursued in the warmth and light of the drawing office, but a ghastly experience when the partnership has been dissolved and man and draught are chasing each other!

* * *

"Marksman" had always been under the impression that in draughts everything was done strictly on the square, the moves being in an orderly fashion. That evening's experience brought disillusionment, for "Marksman" went round the house in circles, right-angles, left-angles, and rectangles, pentagrams, pantechnicons and permanent waves, but the source of the draught remained an unsolved mystery. Draughts are apparently borne, not made, and on reflection it certainly seems that they have to be borne, for nobody appears to be able to contend with them adequately. Bankers and people of that sort, of course, revel in them, and keep a big stock ranging from eight to ninety days. One evening was quite enough for "Marksman"!

* * *

Seriously though something ought to be done about it, and "Marksman" hopes his readers will rally round with gum bottles, gluepots and paste, brown paper and scissors. We must stick to our determination to rid the world of these blasts of ill will, and the surest method is to stick the brown paper on every crack and cranny. Do your duty and blow the consequences, for they will blow you all right by jimminy! Remember that a draft on the Bank of England may be a very desirable thing, but a draught on the back of the neck may prove to be a stiff liability. Draught is good even in half measures, but draughts are bad. That may seem singular on a casual perusal, but there is always safety in numbers.

* * *

Some superlatively intelligent reader will doubtless ask where draughts go to in summer time? Well, they are still on the board, so to speak, but the poets take a hand in the game and rename them zephyrs, gentle breezes and what not. Let us remember, too, that a ship has a draught, but a draught of fish is something quite different either from that or a draft of soldiers. You may draft a letter to a client calculated to raise a bit of a breeze, but that would not be a draught. Then there is the draft horse, but this particular quadruped would never put the wind up the bookies. On the whole, this seems to be rather a breezy column and "Marksman" has perhaps deserved the epithet of "windbag."

MARKSMAN.

(*Concluded at foot of previous column.*)

The History of the Development of Ironfounding in Sheffield

A TESTIMONY TO ANCIENT CRAFTSMANSHIP

MR. C. D. POLLARD, who presided over the opening meeting of the Sheffield Branch of the Institute of British Foundrymen, in the unavoidable absence of Mr. W. T. Kitching, the retiring Branch-President, on behalf of the Branch, extended a hearty welcome to Mr. Hurst. They hoped he would have a happy year, both as Branch-President and as the national President, when the time came for him to take up that office. Mr. Hurst could be assured of the full support of his own Branch in the high office he was being called upon to fill.

MR. HURST acknowledged the kind wishes thus expressed, and proceeded to deliver his presidential address, which has appeared in our issues of October 11 and 18.

At the conclusion of the lecture, the CHAIRMAN said that no words of his could express adequately the appreciation of the meeting for the splendid address that Mr. Hurst had given them. The amount of time that Mr. Hurst must have spent in delving into ancient history would probably never be known. It was gratifying to know that that history would now be on the records of the Institute. The Paper was worthy of all the publicity it could possibly receive. As he noted the illustrations on the screen of some of the fine work done in the old times, and realising what we were doing at the present time with fluidity tests, he wondered what tests those old craftsmen adopted before attempting some of the splendid specimens which Mr. Hurst had shown to them.

Type of Old Patterns Used

MR. M. BROWN remarked that the address was a refreshing variation of the usual type. It made them feel that they were very small fry after all when they found the articles that were produced 200 or 300 years ago. In regard to the ornamental work especially, he wondered if they were to assume that the patterns were moulded in clay or some type of wax that could be melted out of the mould. Surely they were not carved in wood before they were used? It would be interesting if Mr. Hurst could enlighten them on that point.

MR. HURST replied that wax and plaster patterns were principally used. In the case of standard articles they ultimately managed to get an iron master-pattern. Invariably in the case of individual designs—and a great many of the pieces of work shown were the expression of individual designers—they were moulded in wax or clay primarily, and were exclusive designs, probably only once cast off.

MR. J. ROXBURGH remarked that workpeople at the Thorncliffe works of Messrs. Newton, Chambers & Company always referred with pride to the old stone cupolas that were formerly there. He believed the ruins still existed. He wondered if Mr. Hurst could give the date of those cupolas. Then Mr. Hurst had made reference in his early history to the art of dry-sand moulding. He (Mr. Roxburgh) felt very much interested in that because he was under the impression that green-sand moulding was first invented, and that dry-sand moulding was not introduced until comparatively recently. Another point he would like further information upon was in regard to forges. They were aware of the existence of forges in the earlier history of the iron and steel industry, and he wondered if Mr. Hurst had been able to find out in his investigations anything concerning the manufacture of any very large castings in the early history of ironfounding, when they had poor facilities for handling such work in the foundry and as regards transport. Perhaps Mr. Hurst might have some information relating to anvil blocks or any castings of a similar nature. They knew that in those forges some kind of block would be required, and, if any particulars could be traced of such castings, together with some details of their manufacture, they would be of great interest to Mr. Roxburgh personally and probably add considerably to the history of local founding.

MR. HURST said that the time available for his Paper did not permit references to many more interesting items in connection with the early operations of the Sheffield iron foundries. He was well aware of the old stone cupolas at Thorncliffe, but had no information as to the date of their origin. On the subject of large castings, he would point out that Thorncliffe had on record one of 5-ton weight. Probably there were others as large. There must have been many more castings of a similar type, because in those early days shafts and axles were generally made of cast iron, and those of them who had seen any old beam engines that were still in existence knew that they must have required large castings. It was interesting to note that, with the development of the steam engine, steam rolling mills were installed in the Sheffield district. Most of the foundries then in existence were also engaged in the rolling industries, and whenever they ordered rolling-mill engines, they stipulated that they should make their own castings. This caused James Watt considerable difficulty, as at that time the only person who could bore cylinders to his satisfaction was John Wilkinson at his works near Darlaston, and Wilkinson held the patents for the boring machines, which, of course, were the equivalent of the modern boring mill. At any rate, Walker's, when ordering a mill engine, stipulated that the cylinder would be cast and bored in their own works. Some of these castings must have been of a huge size, and while he had no evidence of details of their manufacture, it was obvious that their forefathers were not afraid to tackle a big job.

DR. J. G. A. SKERL stated that he was only that week in a small non-ferrous foundry, which had originally been used for the making of cast-iron knives and where only the remains of the annealing oven were now to be seen. After listening to the lecturer, he could not help thinking that such a subject as the history of foundry work in a particular area was pre-eminently one which would allow of the greatest co-operation between all members of a particular branch, and upon which the local branch of the Institute could present a Paper at intervals, for example, at the Annual Conference, when it was held in its area. He greatly appreciated Mr. Hurst's lecture, since it gave a new light on the past and a great impetus for the future to all interested in cast iron.

MR. F. E. STEELE said it had been very interesting to listen to Mr. Hurst. What had struck him (Mr. Steele) particularly was the wonderful skin the castings had in view of the period in which they were made. In these days we talked so much about synthetic sand and that kind of thing, and it was remarkable to reflect that those castings had come from that period with such a wonderful skin. The people in those days must also have known something about fluidity and pouring temperatures, and must also have known more than we generally gave them credit for about the mixture of sands. He himself had wondered if Mr. Hurst would say something about the large castings that were made in the old days in Sheffield. He (Mr. Steele) had in his possession a cutting from a daily paper describing a casting that was made some years ago in a foundry situated, he believed, in Savile Street. He believed that the casting was a anvil block. It weighed somewhere in the region of 156 tons. He believed he was right in saying that in order to move the casting they had to take out the end of the foundry, and it took three weeks to move it 300 to 400 yds.

MR. ROXBURGH, alluding to the use of green sand, said there was no doubt that the art of green-sand moulding was tending to die out to-day. He thought they ought to give the people of the earlier days credit for the heavy castings they actually turned out. There was no doubt that to-day when they had a large job to make in the foundry they immediately flew to dry sand for safety. In the olden days the individual skill of the moulder was in the ascendancy, and they were able to manufacture intricate and heavy castings in green sand—castings that to-day would in all probability be made in dry sand.

MR. A. WHITELEY (Senior Vice-President) proposed a vote of thanks to Mr. Hurst and described the Paper as having been most fascinating.

MR. ROXBURGH (Junior Vice-President) seconded, and the hon. secretary (MR. T. R. WALKER) supported the proposition, which was cordially carried.

MR. HURST acknowledged the compliment.

On the motion of MR. HURST, a resolution of thanks was accorded Mr. Kitching for his services as President during the past year.

Catalogues Received

Fans. We always appreciate the publicity matter emanating from James Keith & Blackman Company, Limited, 27, Farringdon Avenue, London, E.C.4, because of its straightforward, businesslike character. The latest example received is Y 49, covering high-efficiency-type blowing and exhausting fans. We are extremely sympathetic towards the makers of these, because of the conditions under which they are expected to work efficiently. They are often erected at almost inaccessible spots high up on shop walls; placed at the end of palpably inefficient duct work and often have to encounter acrid- and gritty-air currents. We are reasonably certain that it would pay foundry owners and executive officers to consult the fan manufacturers on their problems instead of leaving the job to a "local plumber" type of individual. The corrosion problem in duct work, about which from time to time we receive inquiries would be non-existent. This twenty-four page catalogue gives the fundamental characteristics a wide range of blowers, including a line specially designed for cupola operation. It is well worth while obtaining this brochure and according it a permanent position in your catalogue file on account of the valuable technical data it contains.

Gears. Messrs. David Brown & Sons (Huddersfield), Limited, Park Works, Lockwood, Huddersfield, have achieved as high a reputation for their publicity as they have for the quality of their engineering productions. Their most recent publication, "Automobile Gears and Gear Units," is a particularly brilliant example of modern engineering publicity, viewed from no matter what angle. It runs to twenty-four pages and is beautifully illustrated.

Chilean Iron and Steel Industry

The Chilean Government is arranging to grant a further subsidy of approximately $2,000,000 to Chile's iron and steel industry to save it from closing down, according to reports from Santiago. The Government will receive shares of the Cia. Siderurgica de Valdivia, at Corral, in exchange for the subsidy, which will be used to purchase steel rolling mills. Machinery and equipment for the rolling mills will be allowed to enter duty free.

A New Slush Casting Process for Shoe Lasts

An interesting process has been developed for the casting of thin-walled hollow articles of cast aluminium and the like. The process is specially suited to the production of lasts for use in the shoe industry, although it is also applicable to the production of other hollow thin-walled castings, more especially of relatively simple form, for example, flasks.

The mould which is used, and which is without a core, is of metal, and is constructed in two or more portions, which are readily assembled to form the closed mould, and are also readily separated from one another to open the mould. In the case of a mould for a shoe last, the mould is conveniently in two portions, with the joint between them disposed in a plane extending vertically of the mould along the centre thereof. When closed, the two or more parts of the mould are held together by some simple device, such as a clamp.

The mould, in the case of a shoe last, is formed at the top with a filling inlet for the casting metal disposed immediately over the heel portion of the interior of the mould, and at the bottom with an outlet for the casting metal situated immediately beneath the tip of the toe portion of the interior, the outlet communicating with a riser extending up to the level of the top of the inlet. The inlet is of sufficient size to enable the mould to be filled rapidly and easily, but is preferably of limited dimensions so as to prevent the flow back of metal collected in the riser leading from the outlet. The inlet and the outlet of the mould are both situated in the joint between the two mould portions.

In the use of the mould, cast aluminium, or an equivalent metal or alloy, is poured into the mould through the inlet until the mould is completely full. The filled mould is thereupon immediately tilted or turned over to empty it, through the outlet and riser, of the whole of the molten metal which has not solidified upon contact with the interior surface of the mould. The mould is then opened and the thin hollow aluminium or other casting formed therein is removed, trimmed and finished.

It is sometimes found that, even with a relatively large outflow opening for the still fused metal, the outflow of the metal is insufficiently free and rapid, especially in the case of aluminium-alloy castings and castings of similar relatively high-melting-point metals tending also to solidify rapidly, to enable a satisfactorily uniform wall thickness of the casting to be obtained. In such cases, a modification of the process consists in hastening the exit of the fused metal from the mould by compressed air introduced into the mould, immediately upon overturning thereof, by way of an admission passage located in the lower part of the mould, so as to be situated when the mould is turned over above the level of the outflowing metal, and projecting a short distance into the mould interior.

The air-admission passage is usually situated at any convenient position in the mould, and, if necessary, in the case for example of complicated moulds, there may be several air-admission passages so disposed, having regard to the shape of the mould interior, as to secure to maximum degree the desired uniformity of wall thickness of the casting.

The aperture formed in the wall of the casting by the presence in the mould of the air-admission passage is closed by a cork or the like after the casting has been removed from the mould.

The process is very economical, as two men can easily work it and obtain a fairly high output, and in the case of a shoe last, owing to the relative disposition of the inlet and outlet for the casting metal, the inlet above the heel portion of the mould and the outlet below the tip of the toe portion, the wall thickness at the toe end of the last is somewhat thicker than elsewhere, which is what is generally required of a satisfactory hollow metal last, the thickness, however, of the remainder of the last being highly uniform. Moreover, the outlet being below the toe portion of the mould, the upper surface of the toe end of the last is initially in a smooth condition, that is to say when cast, and the necessary welding in the finishing of the last, to close the opening in the wall thereof which is produced upon cutting off the riser, is situated on the underside of the last where smoothness is not so important a consideration as it is upon the upper surface of the last.

Service Characteristics of the Light Metals and Their Alloys

This report, just issued by the American Society for Testing Materials, was prepared to present in convenient, concise form essential technical data and information for aluminium, magnesium and their more important alloys. It culminates two years' work on the part of the members of A.S.T.M. Committee B—7 on Light Metals and Alloys, Cast and Wrought, with the American Foundrymen's Association co-operating, especially on material relative to casting alloys.

The publication is arranged in four parts: metallurgical characteristics, industrial requirements, surface protection and tabular data. Under the first-named part there is discussion of chemical composition, heat-treatments, welding, etc.

The section on industrial requirements evaluates the usefulness of light alloys in certain fields, including aircraft, automotive, general structural and architectural work, railway equipment and household appliances.

While for most applications no surface protection is used, there are times when this is desirable. The discussion in the report covers painting, anodising or the artificial production of an oxide coating and electroplating. The latter two items apply specifically to aluminium.

The section on tabular data includes 16 extensive tables covering trade designations, nominal compositions, physical constants, typical mechanical properties and foundry characteristics of casting alloys. A bibliography completes the report.

The actual work of compiling the data and information was in charge of a committee consisting of Mr. A. L. Boegehold, General Motors Corporation; Mr. D. L. Colwell, Stewart Die Casting Corporation; Mr. W. H. Dix, jun., Aluminum Company of America; Mr. J. A. Gann, The Dow Chemical Company; Mr. J. B. Johnson, Material Section, Material Division, Air Corps, U.S.A.; Mr. H. S. Rawdon, National Bureau of Standards; and Mr. Sam Tour, Lucius Pitkin, Inc.; Mr. T. D. Stay, Aluminum Company, served as representative of the American Foundrymen's Association.

Heat-treated Brake-drum Alloy Castings

Messrs. Ley's Malleable Castings Company, Limited, Derby, England, have issued an interesting brochure describing "Lepaz" heat-treated brake-drum alloy castings, which are a marked advance on pressed-steel and cast-iron brake drums. "Lepaz" is a high-tensile heat-treated alloy which offers a combination of other desirable physical properties, with a high and constant coefficient of friction, not subject to "fading," and which is not materially diminished by temperature rise, and is not dependent on a bedding-down taking months to acquire. Its ultimate tensile strength is 35 tons per sq. in.; the yield point, 19-20 tons per sq. in.; elongation, 6-8 per cent. The machinability is similar to that of mild steel, but comes away rather more cleanly. Tests conducted on special testing equipment, far in excess of normal road usage, show that the resistance to wear of "Lepaz" is similar to that of cast iron, but that "Lepaz" develops a better surface and develops it quickly.

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Machine Tool Castings

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Your interesting leading article on machine tools and castings raises a point which should not be allowed to pass without comment by production engineers. The machining allowances which the latter expect and demand from the foundry are of necessity governed by the capabilities of the foundry in setting and maintaining standards of dimensional accuracy in the placing of cores, and in ensuring that the cores remain where they were placed. The trends in production engineering are serving to emphasise the lag of the foundry behind the machine shop in these matters of repetitive accuracy, the reason, as you have indicated, being the limitations of the sand mould.

This being the case, it is surely desirable that considerably more attention should be given to the possibilities of casting grey iron in permanent moulds. The die-casting of the non-ferrous alloys has resulted in the elimination of machining operations in many cases and in greatly improved dimensional accuracy, but there is as yet no sign of similar developments in the iron foundry. The only visible indication of improved practice is the advance made by isolated foundries in the use of sand moulds built up in sections from oil-sand cores machined to size—a practice which enables them to quote machining allowances in hundredths of an inch—but this lead has not been followed to any extent by the industry in general. The centrifugal casting process represents a considerable advance as far as cylindrical shapes are concerned, but there is a very real need for similar developments for the more general run of castings.

While sand remains the moulding medium, trouble from both inaccuracy and the presence of sand in the casting is bound to continue, and to give engineers the impression that the foundry is not really interested in the attainment of the maximum possible efficiency and accuracy. Sand, like beer, may be best, but its place is on the seashore rather than in the modern foundry.—Yours, etc.,

F. H. GREENWOOD.

Bedford.

Boiler Explosions

The Report upon the working of the Boiler Explosions Acts, 1882 and 1890, during the year ended December 31, 1933, states that the term "boiler" is defined as meaning any closed vessel used for generating steam, or for heating water, or for heating other liquids, or into which steam is admitted for heating, steaming, boiling or other similar purposes. It includes, therefore, not only boilers used for supplying steam to machinery but also tubes of steam ovens, heating apparatus, steam pipes, stop-valve chests, steam-heated hot plates, calenders, drying cylinders, economisers, steam-jacketed pans, rag boilers kiers and stills. Seventy-nine boiler explosions, which occurred during the year under review, were the subject of inquiry under the Acts. Thirty-seven explosions resulted in loss of life or in personal injury, eleven persons being killed and fifty injured. The eleven deaths were caused by seven explosions, of which four occurred on land and three in ships. In three cases formal investigations were held. An appendix to the Report gives the total number of explosions dealt with since the passing of the Boiler Explosions Act, 1882, number of lives lost, and number of persons injured. In the 51½ years ended December 31, 1933, there were 3,357 explosions, or an average of 65.2 per annum; 1,098 lives were lost, an average of 21.3; there were 2,727 persons injured, an average of 53. Copies of the Report may be obtained at H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. (Price 9d. net.)

The Testing of Steel Foundry Sands, and the Control of Supplies by Specification*

By T. R. Walker, B.A.

Nowadays, the supply of most commodities to steelworks, ironworks and other industrial organisations is controlled by specifications governing the nature and standard of successive consignments, according to specifications of quality agreed upon between the seller and the purchaser. Usually, these specifications and their implications are well understood on both sides, and generally speaking there is little difficulty in supplying a commodity suitable for its intended purpose, and which has reasonably the same properties in successive consignments. Foundry sand has remained a commodity which is used in very large amounts, but scarcely ever bought or sold to specification requirements. In most cases foundries restrict themselves to buying sand from one or two particular concerns, and when ordering sand say very little beyond: "The mixture as before." A rival supplier asking for an order is usually given a sample of sand which has proved satisfactory, and asked to supply one like it, the extent of the likeness being frequently limited to visual inspection and "feel." He may have the sample analysed, and supply a sand of a similar chemical analysis, but the chemical analysis of a foundry sand is by no means the only factor in determining its behaviour in actual use in the foundry.

It is proposed first of all to describe briefly the qualities of a sand which influence its behaviour in use in the foundry, and to show that these qualities are, in the main, susceptible to numerical evaluation. After this, suitable methods of examination of sand supplies will be briefly described, and the advantages of controlling supplies by specification will be pointed out.

Fundamental Properties

The important properties of a moulding sand include the following:—Its refractoriness, or resistance to high temperatures; its mechanical strength in the green and in the dried states; its permeability to gases; its plasticity; its grain size and its consistency in successive consignments or batches. These properties are, of course, not independent of each other.

The refractoriness of a sand depends partly on its chemical composition, and partly on its constituents. The refractory constituent is quartz, and practically all the other accessory substances have a lower fusion point than quartz, their effect on the refractoriness of the sand depending on the way in which the elements they contain are combined. For example, lime present as calcium-oxide has a high fusion point, but present as calcium-silicate fuses much more easily. The refractoriness of a sand is more important for a steel foundry than for iron or non-ferrous work, where casting temperatures are substantially lower. The sand should strip well from the castings, that is to say, it should not be burnt on to the surface of the steel or other metal. This is largely a question of the refractoriness of the sand. Burning on does not, however, depend solely on the properties of the sand. It is influenced by the size and shape of the casting, and also depends on the length of time the sand is kept at a very high temperature in contact with the metal. As steel is cast at the highest temperature of common metals, burning on of the sand is more common with steel castings than with others. A small amount of burning on, however, is not so important as is often claimed. When steel castings are annealed, as they all ought to be, the sand and scale fall off very easily at the same time. Naturally, the temperature of casting also affects the amount of burning on, which increases as the temperature rises.

The Nature of Bond

The bond, or material which holds the sand together, consists largely of hydrated and colloidal oxides of aluminium and iron, and is present round each grain of sand. A bond due largely to iron oxide gives the sand a smooth feel, whilst a sand containing mostly an aluminium bond feels harsher and dries more rapidly on exposure to the air. On moderate heating, part of the water is driven off, but on cooling the bond may be regenerated by taking up more water. On strongly heating, however, much of the bond is for all practical purposes destroyed. In the same way, if gypsum is moderately heated, part of the water is driven off, leaving plaster of Paris, which, on cooling, will again combine with water and set hard. If, however, the gypsum is strongly heated, all the water is driven off, and the resulting material will not, on cooling, readily combine with water again. In the green state, a sand must be strong enough to be moulded; in the dried state, it must be strong enough to withstand the pressure of the steel. When dried, it must also have a hard surface, to withstand the rush of liquid metal.

TABLE I.—*Permeability of Sand Mixtures.*

Sand.	Permeability number. A.F.A. apparatus.	Green strength, lbs. per sq. in. 2¼ in. by 1¼ in. specimen.	Relative density.	Water content. Per cent.
Leighton Buzzard	501	4.0	1.67	2.5
Silica sand No. 9, with 4 per cent. Bentonite ..	501	4.0	1.67	2.5
Ryarsh silica sand with 4 per cent. Bentonite ..	50	3.25	1.47	3.8
	53	3.25	1.48	3.6
Durham milled sand	36	21.5	1.91	10.8
	38	22	1.94	9.84
Leighton Buzzard, 50 per cent.	131	18.5	1.86	6.0
Durham, 50 per cent.	131	19	1.89	6.0
Ryarsh, 50 per cent.	33	14	1.76	6.25
Durham, 50 per cent.	33	15.5	1.78	6.25

A sand should be plastic, that is, it should ram easily, and stay where it is put, and it should not be resilient or springy. This is especially important where squeezing machines are being used.

The Water Content

A sand mould, even when dried, contains an appreciable amount of water. The layer of sand nearest the steel or other metal is strongly heated, and the water it contains is vaporised. One volume of water gives 1,700 volumes of steam at 100 deg. C., and this increases to about 6,000 volumes at 1,000 deg. C. Quite apart from any other gases which may be generated, it is necessary for all this steam to escape, either through the metal or through the sand. It is, therefore, very desirable that the sand should be as permeable as possible to the passage of gases. Actually, as the steam moves into the mould from the mould surface, it meets cold sand, and much of it condenses. The permeability of the mould some distance from the face is, therefore, less important than that of the sand which is very near to the molten metal.

Troubles from Variation

It is important that successive consignments of sand should have the same properties. Small variations in the sand, which may appear unimportant to the supplier, often cause trouble in the foundry, where identical results are expected from successive supplies of sand when given precisely the same treatment. Moulders as a class are conservative, and obtain better results from a moderate sand which is uniform in its properties, than from one which varies from time to time, even though each particular consignment may be good when used in some particular way. This is simply because all consignments are treated alike, and, if they vary, the treatment which suits one lot will not give equally good results with the next. This is also important when new supplies of sand are being tried out in a foundry. The tendency is for a new sand to be given a bad name because it does not give good results when treated in exactly the same way as the sand already established.

The grain size of the sand should be as uniform as possible, to ensure good permeability. If the sand is made up of grains which are of varying sizes, the small grains fill up the spaces between the larger grains and diminish the permeability considerably. For small work, a finer grain size is permissible than for large work, as the weights concerned are smaller, the sand is at a high temperature for a shorter time, the amount of gas to be dealt with is less, and the surface of the casting better than is possible with a large grain size. For green-sand work, the grain size should be larger, as more water is present in the sand than is present in dried moulds, and, generally speaking, the larger the grain size of the sand, the greater is its permeability to gases.

Geological Formation of Moulding Sand Deposits

Natural moulding sands are largely formed by the natural denudation of the land from the decomposition of massive rocks having a quartz base. The particles are carried down rivers into the sea. When they reach the estuary or the sea, the velocity of the stream is checked, and the particles are deposited in order of size, the largest and heaviest first, and the deposit becoming finer and smaller in grain size as the distance from the land increases. Natural sands, therefore, vary along the line of deposition, not only in size of particle, but also in the amount of finely divided bonding material they contain. They also gradually thin out sideways. It is thus not surprising that when such sand beds have been raised above the sea-level by subsequent earth movements, the deposit is not uniform, and a supplier who commands a deposit of good moulding sand which is more or less uniform in reasonable quantities is fortunate indeed.

The combination in a sand of grains of a good size and shape, uniform in size, accompanied by a good type of bond in the correct amount, is not usually met with in nature, and most of the moulding sands employed in a foundry are compounded. For example, a very strong natural sand, rich in good quality bond, can be milled with silica sand (containing no bond) of a similar grain size, and these will give a compound sand of good quality and a strength which can be

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* A Paper read before the Sheffield Branch of the Institute of British Foundrymen, Mr. J. E. Hurst presiding.

adjusted to suit the intended purpose. More than two sands may be mixed; for example, a sand containing a bond which is mostly aluminous may be mixed with sand with a predominant iron bond to give a compound sand with a balanced bond, this mixture then being diluted to a suitable strength with silica sand, the silica sand also serving to increase the refractoriness of the whole mixture. In all such mixtures, sands of similar grain size should be used, so as not to diminish the permeability of the whole.

The last sentence perhaps needs a little qualification. If a medium-sized moulding sand is milled with a very coarse silica sand, the permeability of the resulting mixture will be intermediate between that of the two original sands. As a result of the mixing, therefore, the permeability of the moulding sand has been improved, whilst that of the silica sand has been diminished. If, however, the same moulding sand is milled with a fine-graded silica sand, it is possible for the permeability of the resulting mixture to be lower than that of either of its constituents. This is shown by Table I.

The shape of the sand grains and the nature of their surface are also of some importance. Spherical grains touch one another at a minimum number of points, and the more angular the

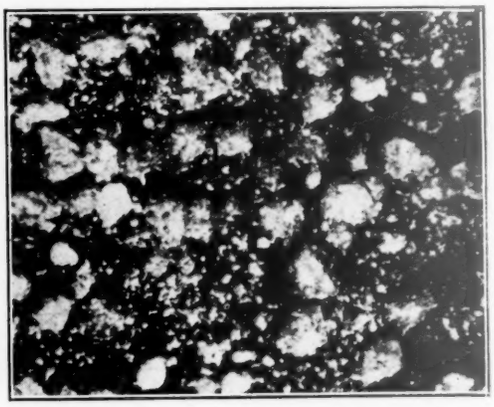

FIG. 1.—BELGIAN NATURAL MOULDING SAND. × 30.

grains, the more closely will they fit together, the sand becoming less open. Sand grains with a rough surface produced, for example, by partial erosion, retain a layer of bonding material much more tenaciously than grains with a very smooth surface. Variations in grain shape and nature of surface can at present scarcely be given numerical or quantitative values, but they have their effects on the results of sand examination for other properties.

Fig. 1 shows a Belgian natural moulding sand, the grains being covered with a substantial layer of clay, and a good deal of loose clay being visible as a fine ground mass.

Fig. 2 shows the sand grains from the same sand when all the clay has been removed. The grains are remarkably uniform in size.

Moulding sands may also be made by starting with silica sand, which is highly refractory and contains no bond, and mixing this with bonding material so that each sand grain is coated with the bond. The usual bonding material used in this way is clay. This must be as refractory as possible, so as not to interfere seriously with the refractoriness of the sand, and must be as plastic as possible, to provide the maximum amount of bond for the minimum amount of clay added, again so as not to diminish the refractoriness of the sand more than is necessary. These two requirements of refractoriness and plasticity in the clay are to some extent incompatible. Two clays commonly used in this way are ordinary fire clay and ball clay. To obtain equivalent effects as bonding material, a good deal more fire clay than ball clay is required, so that though ball clay is much more expensive than fire clay, the fact that so much less is necessary means that the effect on the refractoriness of the sand is less, and it is therefore preferable to use the more expensive clay. For reasons both of expense and refractoriness as little clay as possible is added.

Bentonite is a highly-plastic clay which has been much used for this purpose in America, and which is being employed to an increasing extent in this country. Colbond and Wilkinite are materials of a similar nature of more recent introduction. Such silica-sand-clay mixtures are prone to dry rather quickly on standing, since their bond is essentially aluminous in nature, and they have a harsh feel compared with ordinary moulding sand. On drying they tend to develop a weak face on the mould, which is easily rubbed away. They are much improved by the addition of a small amount, say ½ per cent. of a binding material, such as wood-pulp extract, not only in the above respects, but also in green strength.

Properties of Synthetic Sand

Table II shows the result of adding different clays to the same silica sand. The chemical analyses of the clays are given, but it must be emphasised that the chemical analysis of a clay is not a reliable guide to its physical properties except in a general way. Sheffield fireclay gives the worst results. The Kingscliffe clay has not been found to be suitable for low-temperature work of this kind, but is satisfactory for binding high-temperature refractory materials such as silica bricks.

Considering steelfoundry sands in particular, therefore, the most important factors in its good behaviour or otherwise in the foundry are its chemical analysis, refractoriness, mechanical strength and permeability. In the green state, the mechanical strength depends not only on the nature and amount of the bonding material present, but also on the water content and on the density to which the sand is rammed. The permeability to gases is also influenced by the water content and ramming density, as well as by the grain size of the sand. The water content and rammed density must therefore be included in the properties to be quantitatively determined in any complete examination of the properties of a foundry sand.

Reasons for Chaotic Supply

Provided that for a given commodity the methods of examination are universally agreed, and that consistent results can be obtained by different operators, working with similar apparatus, in widely-separated places, there is no reason why such a commodity should not be bought and sold according to precise and well-defined specifications. The fact that throughout the world there is very little buying or selling of foundry sands on a specification basis appears at first sight somewhat astonishing, in view of the very large tonnage involved. The reasons for this state of affairs are firstly that it is only during recent years that the study of foundry sands has been placed on a scientific basis, and that apparatus specially designed for sand testing has been elaborated, and secondly, that owing to the recent growth of the science of foundry-sand testing, there is no universal agreement as to the type of apparatus to be used for testing the different properties of foundry sands.

The chemical analysis of a sand can easily be carried out in any ordinary chemical laboratory. The mechanical grading of the sand particles, *i.e.*, the division of the sand, by percentages or otherwise, into amounts of grains present whose size is between certain limits, is easily done, but even here there is no universally-accepted method of recording the results, or of carrying out the testing. At this point a division must be drawn between the examination of sands for foundry-control purposes, and their investigation from a research point of view. For the control of sand for use in the foundry, and for the examination of consignments being received, the methods employed must produce quick results with as great accuracy as can be secured in a short time. In research work, on the other hand, the methods used should be founded on accepted scientific principles, and accuracy is in this case far more important than the time taken.

Water Determination

The amount of water present as such in a sand can be determined in any laboratory in about an hour, and this method, in which the sand is heated to 105 to 110 deg. C. until there is no further loss in weight, is quite applicable to the control of consignments of foundry sands. For use in examining batches of sand actually being used in the foundry, however, especially for green-sand work, an hour is far too long a time, and the result for water content may be secured in about 5 min. by the use of the "Speedy" moisture tester, in which a known weight of sand mixed with excess of calcium carbide in a closed container evolves acetylene, the increase in internal pressure due to the evolution of the gas being read on a dial, attached to the base of the container, which is calibrated to read percentages of moisture in the sand directly.

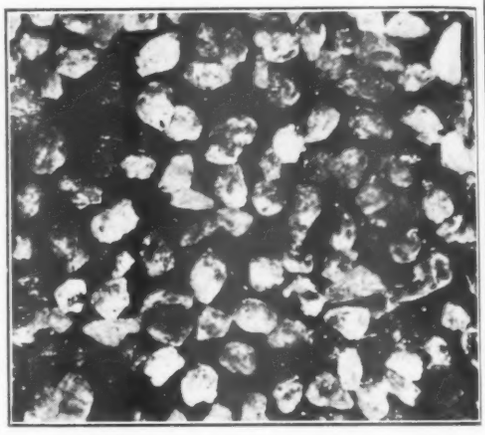

FIG. 2 SHOWS THE SAND ILLUSTRATED IN FIG. 1 AFTER REMOVAL OF THE CLAY GRADE. × 30.

Mechanical Testing

The mechanical strength of a moulding sand is very different in the green and in the dried states; the sand has, in fact, properties which are substantially different in the two states. When dried, it is a brittle material, resembling in many respects concrete, while in the green state it is partly brittle and partly plastic in nature. It does not follow, therefore, that the same methods would be equally suitable for testing green and dried sands. For routine testing, whether of incoming consignments or of sand in use in the foundry, it is sufficient to test the green strength of the sand. The relation between the mechanical strength in the green and in the dried states, whilst varying appreciably with different types of sands, is yet sufficiently well known to allow the deduction to be made that, if the green strength of any given specimen of sand is satisfactory, the mechanical strength in the dried state will present no difficulties. From the control of supplies point of view, therefore, it is sufficient to determine the green strength of a sand under examination.

The mechanical strength may be determined by tensile, compressive or torsional methods, but the apparatus required, and the skill in its manipulation demanded, in the determination of the green strength of a sand in tension or torsion, preclude the use of these methods of testing for foundry control purposes. Ramming a cylindrical sand specimen and then applying pressure axially until it collapses are both easy, but in

practice the results vary not only with the method of ramming, the water content, and the density to which the sand is rammed, but also with the ratio of length to diameter of the specimen. The specimen adopted by the American Foundrymen's Association is a cylinder 2 in. by 2 in., with its height equal to its diameter, whilst that recommended by the British Cast Iron Research Association is a cylinder approximately $2\frac{1}{4}$ in. by $1\frac{1}{8}$ in., the exact size being 2.256 in. by 1.128 in., with the height twice the diameter.

TABLE II.—*Mixtures of King's Lynn Silica Sand and Clay.*

Mixture.	Permeability number. A.F.A. apparatus.	Green strength. 2 in. by 2 in. specimen, lbs. wt.	Green strength. $2\frac{1}{4}$ in. by $1\frac{1}{8}$ in. specimen, lbs. per sq. in.	Relative density.	Water content. Per cent.
95 per cent. sand with 5 per cent. Barrow clay	295	5.5	2.5	1.63	2.72
		5.5	2.75	1.64	
90 per cent. sand with 10 per cent. Barrow clay	240	16	7	1.63	4.20
		17	8	1.65	
95 per cent. sand with 5 per cent. Sheffield clay	243	1.75	0.75	1.60	1.90
		2.0	0.75	1.60	
90 per cent. sand with 10 per cent. Sheffield clay	243	3.75	1.5	1.61	2.50
		3.75	1.5	1.63	
90 per cent. sand with 10 per cent. Kingscliffe clay	191	6	2.5	1.66	2.93
		6.5	2.75	1.67	
95 per cent. sand with 5 per cent. Bentonite	321	20.5	8	1.60	2.63
		21.0	10	1.63	
95 per cent. sand with Ball clay	228	16	7	1.63	2.44
		17	8	1.65	

Chemical Analyses of Clays.

Clay.	SiO_2. Per cent.	Al_2O_3. Per cent.	Fe_2O_3. Per cent.	CaO. Per cent.	MgO. Per cent.	Loss on ignition. Per cent.
Barrow-in-Furness	60.80	25.41	2.29	0.70	1.45	4.90
					alkalies	4.37
Sheffield fireclay	47.00	31.28	4.72	0.20	0.80	15.60
Kingscliffe refractory clay ..	85.40	10.20	1.00	0.30	Trace	3.25
Bentonite	60.30	23.44	3.68	1.28	2.24	8.35
Colbond	62.60	23.23	3.57	0.70	2.46	5.55
Ball clay	54.08	31.87	3.73	Trace	Trace	10.18

A.F.A. and B.C.I.R.A. Specimens

When such specimens are loaded, the resistance to compressive stresses and the resistance to shear stresses are both involved, in proportions which vary with the dimension ratio of the test-piece. For all these reasons the standardisation of a green-strength test for sand is not an easy matter, but it is simplified if we consider only tests suitable for control purposes. The A.F.A. test-piece has the advantage that it is of precisely the same dimensions as the A.F.A. permeability test-piece, so that the same specimen may be used for testing both permeability and green crushing strength. Another advantage is that the specimen is subjected to three blows from a standard ram, so that the method of ramming is the same for all specimens, provided that the standard A.F.A. apparatus is used. The B.C.I.R.A. specimen has the advantage that it is probably a more scientifically designed test-piece, in that the dimension ratio between length and diameter of 2:1 probably gives results which are a truer reflection of the properties which are important in the foundry than the A.F.A. specimen, with its dimension ratio of 1:1. A further advantage is that the B.C.I.R.A. specimen may be compressed in several different ways to give any desired degree of ramming, *i.e.*, to give different apparent densities for different specimens. These two points are important where research work in sands is concerned, but are of no particular moment for control purposes. Any specimen may, however, be rammed by hand to a particular relative density without the use of the special rammer designed by the A.F.A.

For control purposes, either specimen may be used, and it may be compressed by the A.F.A. standard rammer, or to a particular apparent density by some other method. In either case the method of applying the compressive load is the same; the specimen is merely put on the platform of a spring weighing balance, such as is used for parcels, and the load is applied by a screw held in a frame, the load required to make the specimen collapse being read directly on a dial attached to the weighing balance. A suitable frame containing the screw by which the load is applied has been designed by the B.C.I.R.A., and may be very easily purchased at a low figure.

The permeability of a sand to gases is naturally best determined by timing the passage of a given volume of gas at a given pressure through a test specimen of the sand. In the apparatus designed by the A.F.A. the permeability specimen is a cylinder 2 in. by 2 in. This is given three blows with a standard ram, and then the time is taken for 2 litres of air to pass through the specimen at a known pressure, which is applied by a small head of water. The figure given may be left in seconds, or alternatively it may be converted into a permeability number. This number is calculated from the following equation.

$$\text{Permeability number} = \frac{\text{No. of c.c. of air} \times \text{height of specm'n in cm.}}{\text{Area of specm'n in sq. cm.} \times \text{pressure in gm. weight} \times \text{min.}}$$

In the case of the A.F.A. apparatus this may be reduced to the following:—

$$\text{Permeability number} = \frac{30072}{\text{Pressure in gm. weight} \times \text{time in sec.}}$$

In an apparatus designed by the B.C.I.R.A. the specimen is a cylinder 20 cm. long with a cross-sectional area of 40 sq. cm., and coal gas is passed through the specimen at a pressure of 7 cm. of water until it ignites at the other end, the time occupied in this passage being noted. In this apparatus the specimen is rammed by hand to any desired limit of density. This piece of apparatus, while very useful for research work, is neither so quick nor so handy as the A.F.A. apparatus, which is consequently preferable for control purposes.

The Richardson Apparatus

It is possible to use the principle involved in the A.F.A. permeability apparatus, without actually using the standard apparatus, which is somewhat expensive. An equivalent apparatus for control purposes, suggested by Mr. R. J. Richardson, can easily be constructed from two large tins, say 5-gallon oil tins, the upper one of which contains water and is connected to the bottom one by means of a pipe, so that air can be pushed out of the bottom tin, by the ingress of the water, through the specimen of sand, the time necessary for a given volume of air to pass through the sand being again noted. This apparatus, which is illustrated in Fig. 3, can be constructed very cheaply, and gives sufficiently accurate results for control purposes. With both the A.F.A. apparatus and that illustrated, the back pressure set up by the resistance of the sand to the passage of air through it may be measured in terms of a column of water, and this is a quicker method of working, though probably less accurate than actually timing the passage of, say, 2 litres through a sand specimen. With the apparatus illustrated, the permeability specimen employed may be either the A.F.A. 2-in. by 2-in. specimen or the B.C.I.R.A. $2\frac{1}{4}$-in. by $1\frac{1}{8}$-in. specimen. Which is employed is a matter of indifference, so long as it is distinctly stated in the record of the results. These specimens are the same as those used for determining the green crushing strength.

Provided that the air is able to flow through the orifice much more quickly than it can escape through the sand specimen; in other words, provided that the orifice is of sufficiently large diameter, it is possible from the observed results of time taken and water pressure obtained using the apparatus illustrated in Fig. 3, to calculate the permeability number in exactly the same way as is done with the A.F.A. apparatus. The two numbers correspond, and the same sand examined on both types of apparatus ought to give the same permeability number. A detailed account of the method of using this modified permeability apparatus is given in Appendix B of the Paper entitled: "Routine Methods of Testing Green Sands," which appears in the "Proceedings of the Institute of British Foundrymen" for 1932/33.

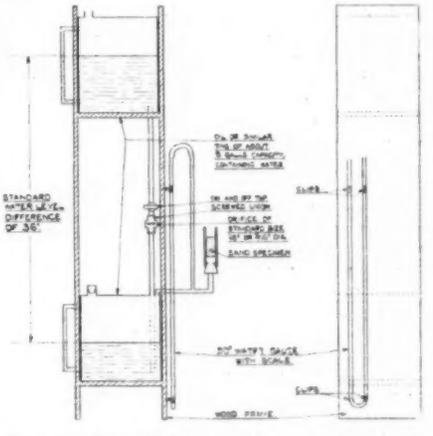

FIG. 3.—SAND PERMEABILITY APPARATUS (AS MODIFIED BY RICHARDSON AND OTHERS).

If the results of permeability determinations are to be compared with those obtained by some other workers, it is best to express the permeability in terms of the permeability number, which is derivable from the results obtained with either the A.F.A. or the modified permeability apparatus. If, however, the results are to be used purely for control purposes in the foundry, and for comparison of successive batches or from day to day, it is easier to use the number of seconds with the A.F.A. apparatus, and the height of the water column in inches with the modified apparatus.

(To be concluded.)

THE HUNGARIAN Rimamuranya Ironworks report a net profit of 504,000 pengö (about £18,000 at par) in 1933-34, as against nil in the previous year. Trade has shown a steady but very slow improvement, which is continuing.

The Determination of Sulphur in Cast Iron

By E. W. Colbeck, M.A., S. W. Craven, and W. Murray*

Introduction

Several methods are in use for the determination of sulphur in cast iron, but none is free from criticism, and the results obtained from them are not always concordant. The tendency to make specifications more rigid has created an even greater need for a method which shall be accurate, easy to manipulate and capable of yielding comparable figures in the hands of different workers.

Present practice for the determination of sulphur includes methods depending on the initial wet oxidation of the sulphur, finishing gravimetrically as barium sulphate and evolution methods depending on the expulsion of volatile sulphur compounds. In the gravimetric methods conditions differ widely from worker to worker, while the evolution methods seldom give general satisfaction. In this Paper both these groups of methods will be discussed and a method suggested which it is believed overcomes some, at least, of their disadvantages.

Evolution Methods

Experience has shown that all evolution methods are uncertain and erratic when applied to cast iron.[1] Several assumptions, difficult either to establish or disprove, are made in these methods. The sulphur must be present in such a form as to be completely decomposed by hot hydrochloric acid and wholly evolved as:—(*a*) H_2S so as to be quantitatively precipitated as a metallic sulphide; (*b*) sulphur compounds soluble in caustic soda, and (*c*) sulphur compounds oxidisable in the cold by solutions such as ammoniacal hydrogen peroxide.

Where discrepancies have arisen between evolution and gravimetric methods, attempts have been made to track them down, and since the evolution method always gives lower results than the gravimetric one, investigations have been directed towards possible sources of loss in the former method. Residues from the attack by hydrochloric acid have been examined for the presence of sulphur; both positive and negative results have been obtained. The speed at which H_2S is evolved is also important. More rapid attack of the iron appears to lead to higher yields of H_2S, so that fine drillings and concentrated acid are desirable.

It has been suggested that the presence of a large amount of carbon in cast iron may be responsible for another source of error. It is quite conceivable that organic sulphur compounds may be formed which are not quantitatively absorbed or precipitated in the receiving apparatus. In steels where the carbon content is much lower than in cast iron, an evolution method will generally give results in excellent agreement with any gravimetric method.

Whatever the reasons for the discrepancies which arise between gravimetric and evolution methods may be, the sources of error in the latter method are so obscure and so numerous as to render it quite unsuitable for the determination of sulphur in cast iron.

Wet Oxidation Methods

One or other of several modifications of the wet oxidation method is usually employed as standard practice for the determination of sulphur in cast iron. In all of these methods attempts are made to reach a compromise which will reduce the effects of unsuitable conditions to a minimum. At their best the results produced represent only a balance of errors; a few of the drawbacks will be considered here:—

(*a*) Small amounts of barium sulphate are precipitated in the presence of large amounts of iron as ferric chloride. Barium sulphate is only sparingly soluble in water, but the solubility is increased considerably by the presence of ferric salts.

(*b*) The amount of free hydrochloric acid is a matter of primary importance. If the acid concentration is too low the precipitated barium sulphate may be contaminated with basic iron salts; if it is too high the resulting solution will exert a marked solvent effect on the barium sulphate, and there will be greater risk of contamination with barium chloride.[2] The correct concentration of hydrochloric acid such that there shall be no occlusion of iron or barium salts and no solvent action on precipitated barium sulphate has never been decided upon. The concentration suggested by different workers varies from 2 to 10 per cent.

TABLE I.—*Comparison of Wet Oxidation and Evolution Methods.*

Cast iron sample.	Per cent. Si.	Per cent. S by Archbutt's method.	Per cent. S by evolution method.
1	1.06	0.035, 0.040	0.031, 0.034
2	2.03	0.072, 0.074	0.057, 0.064, 0.068
3	1.96	0.072, 0.072	0.050, 0.052
4	1.56	0.082, 0.086	0.080, 0.082
5	2.49	0.261, 0.267	0.237, 0.244
6	1.81	0.134, 0.141	0.102, 0.109, 0.118
7	1.53	0.182, 0.183	0.151, 0.172

(*c*) To complete the oxidation, salts such as potassium chlorate are added. This introduces the possibility of further occlusion since according to Mellor[3] salts of the alkali metals are adsorbed by precipitated barium sulphate.

(*d*) The initial oxidation is effected by mixtures of hydrochloric acid and nitric acid and it is afterwards necessary to remove all nitric acid. To do this the solution has to be evaporated to dryness, the residue baked, re-dissolved in hydrochloric acid, and the solution evaporated to low bulk to remove excess hydrochloric acid. All these operations are tedious and are accompanied by danger of losses due to spitting. It is imperative that all free nitric acid should be removed and nitrates decomposed. Quantitative separation of barium sulphate cannot be expected unless this is carried out.[4]

TABLE II.—*Comparison between Archbutt's Method and Copper Ammonium Chloride Method.*

Cast iron sample.	Per cent. Si.	Per cent. S by Archbutt's method.	Per cent. S by copper ammonium chloride method.
8	1.57	0.052, 0.057	0.055, 0.056
9	1.89	0.220, 0.220	0.222, 0.222
10	1.83	0.180, 0.185	0.180, 0.183
11	1.64	0.090, 0.098, 0.092	0.096, 0.095
12	1.05	0.106, 0.108	0.103, 0.105
13	1.24	0.048, 0.054	0.048, 0.048
14	1.06	0.090, 0.091	0.092, 0.092
15	1.68	0.062, 0.059	0.065, 0.066
16	1.84	0.034, 0.042, 0.035	0.038, 0.038
17	2.32	0.077, 0.078	0.074, 0.075
18	2.09	0.041, 0.044	0.039, 0.040
19	1.59	0.051, 0.051	0.051, 0.051
20	2.58	0.103, 0.109, 0.101	0.105, 0.105
21	1.74	0.131, 0.128	0.130, 0.132
22	2.01	0.361, 0.359	0.357, 0.359

(*e*) Opinions as to the best conditions of temperature and volume of the solution in which the precipitation is to be made when large amounts of iron are present, appear to be divergent. Some workers precipitate barium sulphate from 100 mls. of solution at temperatures ranging from 20 deg. C. to steam bath temperature, others from larger volumes at boiling point.

(*f*) In the normal wet oxidation procedure large volumes of acid must necessarily be used, so that the sulphur blank may be not inconsiderable.

(*g*) It is not definitely certain that solution in nitric acid or nitric-hydrochloric acid does not lead to some loss of sulphur by volatilisation. Järvinen[4] discovered as much as 12 per cent. loss in this way, and believes that the sulphur lost is not necessarily organic.

Apart from chemical considerations the great drawback to such wet oxidation methods is the general lack of agreement between worker and worker as to the best conditions to adopt. Until a standard procedure is adopted throughout the iron trade there can be no hope of comparable results.

Theoretical Considerations and Suggestions for a New Method

In the course of a large number of determinations of sulphur in cast irons the authors have found that it is impossible to obtain results that are either accurate or consistent by any method depending on the evolution of sulphur compounds by attack with hydrochloric acid. The unduly large number of possible sources of error and the tediousness and difficulty of manipulation make the wet oxidation method unsuitable. A search was therefore made for a method which should be accurate, easy to manipulate and in which the conditions necessary for the precipitation of barium sulphate could be readily secured.

Cartoceti[5] has reviewed the various methods depending on the direct oxidation of sulphur to sulphuric acid and subsequent precipitation as barium sulphate, having in view accuracy of analysis. He decided that conditions to be aimed at are: (*a*) Complete oxidation of the sample to avoid treatment of the residue; (*b*) complete freedom from nitric acid; (*c*) silica to be rendered insoluble or separated; (*d*) separation of iron, since the hydrochloric acid solution of ferric chloride exerts a not negligible solvent action upon barium sulphate beside contaminating it with basic iron salts; (*e*) an excess of hydrochloric acid is to be avoided, as otherwise precipitation of barium sulphate is incomplete, and (*f*) precipitation should be carried out in the hot.

Of these six conditions the separation of iron is the most difficult to comply with. It is well known that the bulk of the iron can be removed by an ether separation, but this would not do away with the initial oxidation and baking to remove nitric acid, besides increasing the time taken to complete the determination. An excellent method has been suggested by Järvinen[4] who accomplishes the initial oxidation with liquid bromine and precipitates an impure barium sulphate from the resulting ferric bromide solution. The impure precipitate is fused with sodium carbonate in a platinum crucible, iron separated, and pure barium sulphate precipitated from a solution free from iron and of a definite hydrochloric acid concentration. Järvinen[4] claims that this method gives the total sulphur content of a cast iron, but it does not lend itself to routine practice or cases where fair speed is necessary.

It is possible to dissolve out iron by solution of salts of metals possessing a lower solution pressure than that of iron; copper potassium chloride and copper ammonium chloride acidified with a little hydrochloric acid can be used for this purpose. They are better than a simple salt since they prevent the separation of cuprous salts. The addition of hydrochloric acid accelerates the re-solution of any metallic copper precipitated on the iron. Carnot and Goutal[6] have shown that when iron is dissolved in such a solvent the whole of the sulphur remains in the residue, and this suggested the basis of a method of separation of iron prior to the gravimetric determination of sulphur.

A 30 per cent. solution of copper ammonium chloride in distilled water acidified with 5 per cent. hydrochloric acid similar to that used for the separation and determination of carbon was

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first prepared. A clear solution free from residue was obtained without addition of hydrochloric acid, and in it soluble sulphur compounds could not be detected.

Various attempts were made to effect solution of cast iron in copper ammonium chloride; heating the solution was avoided owing to the danger of oxidation. Agitation by a current of air has two disadvantages; solution is comparatively slow, and again there is risk of some oxidation.

TABLE III.—*Percentage S in Several Samples of Grey Cast Iron.*

Method employed.	Sample A.* Si=2.22 per cent.	Sample B. Si=1.08 per cent.	Sample C. Si=1.57 per cent.	Sample D. Si=1.28 per cent.	Sample E. Si=1.89 per cent.
Evolution with absorption in NaOH and titration with iodine	0.065	0.059	0.066	0.109 0.111	0.032 0.038
Evolution with absorption in ammoniacal hydrogen peroxide, and precipitation as $BaSO_4$	0.055	0.049	—	—	—
Copper ammonium chloride method	0.077	0.073 0.073	0.080 0.081	0.127 0.127 0.130	0.046 0.046
Archbutt's method	0.073	0.069 0.080	0.072 0.078	0.134 0.137	0.042 0.048
Järvinen's method	—	—	—	0.125 0.126	0.044 0.046

* This sample actually is "British Standardised Sample of Cast Iron," issued jointly by the National Physical Laboratory and the Iron and Steel Institute, Standard A. S. = 0.075 per cent. and is known to within ± 0.005 per cent.

The procedure finally adopted consisted of shaking the cast iron with copper ammonium chloride solution in a stoppered conical flask at room temperature. This method has two advantages; since solution takes place in an enclosed space the small amount of hydrogen generated by the hydrochloric acid present is preserved, and a reducing atmosphere maintained, while the time taken to dissolve the iron is short. It was found that cast iron, white iron and alloy cast irons containing chromium, nickel, etc., could all be dissolved rapidly if the samples were in a fairly fine state of division. Four grams of a sample which has passed a 22 mesh B.S.S. sieve can be dissolved easily in five minutes.

A suitable treatment for the residue from solution in copper ammonium chloride was next considered. Three methods for the oxidation and solution of the sulphur in this residue are available. It might be fused in a nickel or platinum dish with sodium carbonate and sodium peroxide; this method, however, would introduce sodium salts which might be occluded in precipitated barium sulphate. A blank determination of sulphur on the reagents would also be necessary. Wet oxidation with hydrochloric acid, nitric acid and potassium chlorate might be employed, but this is open to the objections already enumerated. Both from a chemical point of view and from considerations of speed and expense, oxidation by bromine and hydrochloric acid was found to be the most satisfactory. The concentration of hydrochloric acid in the solution in which barium sulphate is to be precipitated can be readily adjusted, absence of salts of the alkali metals secured, and the conditions outlined by Cartoceti fulfilled.

From the above considerations the following method is put forward.

Procedure

Solution required:—A 30 per cent. solution of pure copper ammonium chloride in distilled water acidified with 5 per cent. hydrochloric acid (S.G. 1.16).

Four grammes of the finely-divided cast iron which has been ground so as to pass a 22-mesh B.S.S. sieve are weighed out into a 350-mls. conical flask fitted preferably with a ground-in glass stopper, or else with a rubber bung which has been well boiled in hydrochloric acid. Each bung should be boiled until the acid used gives no reaction for sulphate of sulphide; 250 mls. of the copper ammonium-chloride reagent are added and the flask stoppered immediately. Solution of the iron is effected by vigorous shaking without releasing the pressure in the flask and so maintaining reducing conditions. The insoluble residue is filtered off on to a pad of paper pulp and washed free from iron salts with a cold wash, consisting of 1 volume of acidified copper-ammonium-chloride reagent diluted with 5 volumes of distilled water. This ensures the presence of traces of copper salts while the last traces of iron salts are being washed out. The residue is washed twice with cold water, transferred back into the conical flask, washed down with 30 to 50 mls. of distilled water, and 2 mls. of liquid bromine and 5 mls. of concentrated hydrochloric acid added. The whole is kept on the water bath for ½ hr. Bromine is then boiled off, the residue filtered off through a fine filter paper (Whatman No. 42) and washed with cold water. The volume of the filtrate is raised to 200 mls. with water, the solution heated to boiling and sulphur precipitated from it as barium sulphate with 10 mls. of 10 per cent. barium-chloride solution. After allowing the precipitate to settle overnight, it is filtered off, washed with cold water, ignited and weighed as barium sulphate.

In the authors' experience, they have never encountered interference from silica after treatment of the residue with hydrochloric acid and bromine and evaporation of the filtrate to dryness is considered unnecessary.

When this work first came up for discussion, a search was made in the literature as far back as 1920 for references to the use of copper-ammonium chloride without success. Some time after the procedure given above had been evolved a further and more exhaustive search led to the discovery of a method by F. H. Franklin,[7] published in 1913. In this Paper reference was made to work carried out along similar lines by C. Meineke[8] in 1886. Both these workers made use of initial removal of iron by copper ammonium (or potassium) chloride solution with different treatment of the residue obtained. Meineke[8] dissolved iron in hot acid-copper-ammonium-chloride solution in a beaker, treated the insoluble residue with hydrochloric acid, nitric acid and potassium chlorate, and continued as in the normal wet-oxidation method. This procedure is, therefore, open to the criticisms already mentioned, while no precautions are taken to prevent oxidation during the solution in copper-ammonium chloride.

Franklin[7] dissolved the iron in cold copper-potassium-chloride solution to which barium chloride was added to precipitate any sulphuric acid that might have been formed. The insoluble residue was dried at 100 deg. C., mixed with sodium carbonate and sodium peroxide and fused in a nickel crucible. The melt was dissolved in dilute hydrochloric acid and evaporated to dryness to dehydrate silicic acid. Barium sulphate was precipitated from the solution obtained near its boiling point, 90 mls. of the filtrate contained 1 per cent. hydrochloric acid. The disadvantages of a fusion treatment of the residue have already been considered.

The chief objection to the use of copper-ammonium chloride for the removal of iron seems to have been the possibility of the formation of soluble-sulphur compounds by oxidation.

Meineke[8], however, quotes work by Raschig[9] to prove that, while such oxidation may occur in neutral, alkaline or ammoniacal solutions, it does not do so in acid ones.

RESULTS

Grey Cast Iron

Several modifications of the wet-oxidation method (using mixtures of hydrochloric-nitric acids, etc.) were tried. Archbutt's[10] method was considered the most satisfactory; 10 mls. of 10 per cent. barium-chloride solution were used to precipitate barium sulphate instead of 5 mls. as given in the text; 10 mls. of 10 per cent. barium-chloride solution are used at the National Physical Laboratory.[11]

The sulphur compounds evolved by attack with hydrochloric acid were collected in (*a*) caustic-soda solution followed by titration with iodine; (*b*) cadmium-acetate solution followed by titration with iodine; (*c*) ammoniacal hydrogen peroxide followed by precipitation as barium sulphate. The results obtained with these evolution methods were erratic; Table I gives some of these, and comparative results obtained by Archbutt's method.

Fair agreement was obtained between evolution and gravimetric methods in some cases; in others, as Table I shows, serious discrepancies arose and the evolution method was therefore discarded.

Further work was undertaken to draw comparisons between Archbutt's method and the method depending on solution in copper-ammonium chloride as outlined in this Paper. Some typical results are given in Table II.

Table II shows that in general the agreement between Archbutt's method and the method sug-

TABLE IV.—*Determination of Sulphur in White Iron.*

	Method employed.	R.1. Si = 0.60 per cent.	R.2. Si= 0.52 per cent.	R.3. Si= 0.42 per cent.	R.4. Si= 0.31 per cent.	S.5. Si= 0.70 per cent.	Y.35. Si= 0.68 per cent.	N.1. Si= 0.65 per cent.	N.2. Si= 0.51 per cent.	N.3. Si= 0.54 per cent.
(1)	Archbutt's method	0.15 0.15	0.14	0.10 0.11	0.052 0.052	0.084 0.087	—	—	—	—
(2)	Copper ammonium chloride method	0.19	0.165	—	0.054 0.054	—	0.14 0.14	0.054 0.054	0.165	0.13
(3)	Evolution with absorption in ammoniacal hydrogen peroxide and precipitation as $BaSO_4$	0.14	0.155	0.10	0.050	0.099	—	—	—	—
(4)	Evolution with absorption in NaOH and titration with iodine	0.15 0.15	0.15 0.16	0.094 0.098	0.048 0.052	—	—	0.045 0.044 0.050 0.056	0.13	0.106
(5)	No. 4, preceeded by annealing the drillings with potassium hydrogen tartrate	0.14	—	—	—	—	—	—	—	—
(6)	No. 4, but evolution carried out in atmosphere of hydrogen	0.158	0.158	0.10	—	0.098	0.12 0.12	—	—	—

gested in this Paper is fair. It is, however, noticeable that the figures for the former method are a little less consistent than are those for the latter, and it must be borne in mind that Archbutt's method demands far greater care, attention to details and time, while it is much less easy to manipulate. In obtaining the figures in column 2 of Table II, divergent results were obtained here and there, *e.g.*, samples 11, 16, 20, but those in the third column were secured without having to do one repeat test.

On several samples of cast-iron sulphur has been determined by a number of methods. These results are summarised in Table III.

The figures in Table III illustrate the inefficiency of the evolution method which has already been discussed. Again good agreement is to be noted between the three gravimetric methods, Archbutt's being rather more erratic than the other two.

White Iron

All figures previously quoted in this Paper have referred to grey cast iron; considerable work has been done, however, on white iron and some results for this type of iron are given in Table IV.

Table IV shows that with white irons the disagreement between the various methods is much more marked than is the case with grey irons. In the authors' experience the copper-ammonium-chloride method is the only one that has given consistent results; it will be noticed that this method gave higher results than any other on the iron quoted in Table IV. No greater difficulty was experienced in dissolving white iron in copper ammonium chloride than in the case of grey irons, providing always that the sample was in a reasonably fine state of division.

So far as evolution methods are concerned, the highest figures were obtained when the determination was carried out in an atmosphere of hydrogen. This suggests that in the ordinary way oxidation is not improbable. Results by these methods were again uncertain and erratic, as is shown by the results for sample N1, and in general lower than those obtained by oxidation methods.

The copper-ammonium-chloride method has been extended to alloy cast irons with satisfactory results.

TABLE V.—*Determination of Sulphur in Alloy Cast Irons.*

Type of alloy cast iron used.	Per cent. S by Archbutt's method.	Per cent. S by copper ammonium chloride method.
*1½ per cent. nickel, 1 per cent. molybdenum cast iron	0.054, 0.059	0.056, 0.059
15½ per cent. nickel, 2½ per cent. chromium, 6 per cent. copper cast iron	0.15, 0.15	0.15
1 per cent. chromium cast iron	0.069	0.069
1 per cent. nickel cast iron	0.033	0.031
19 per cent. nickel, 2 per cent. chromium, 7 per cent. copper cast iron..	0.080	0.082
1 per cent. nickel cast iron	0.075	0.075

* The evolution method gave the following results on this sample: Per cent. S = 0.029, 0.037, 0.034, 0.032, 0.044.

The authors wish to express their thanks to the directors of Imperial Chemical Industries, Limited, for permission to publish this work, which was carried out in the research laboratory of their subsidiary company, I.C.I. (Alkali), Limited, Northwich.

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Electric Lighting for Works and Factories

At a meeting of the Illuminating Engineering Society held in London recently, a Report on "Progress in Illumination" was presented for consideration. The Report was prepared by the Society's Technical Committee. We append a few extracts pertaining to factories and workshops.

Referring to general lighting, the Report states that in connection with fittings for general lighting, interest attaches to a series of industrial lighting reflectors introduced last autumn and designed to secure compliance with the I.E.E. rules prescribing that the temperature shall not exceed 120 deg. Fah. These fittings are designed for six types of light distribution and for lamps ranging in consumption from 60 to 1,500 watts. Novel arrangements are embodied to enable the detachment of the lamp and reflector complete for cleaning and maintenance. A new range of porcelain-top dust-tight fittings of high efficiency has been introduced for use in acid or steam-laden atmospheres or in situations in which inflammable dust is present. These are replacing the old and frequently inefficient type of small well-glass fittings, hitherto the only type readily available. A new type of industrial fitting, comprising a blue glass enclosing globe and a white vitreous enamelled reflector, furnishes partially corrected artificial daylight. Improved designs of enclosed diffusing units designed for close ceiling mounting direct on to the conduit and with detachable flanges to simplify wiring have been announced.

Industrial Lighting

So far as can be ascertained, the lighting of new factories, both by daylight and artificial light, is generally satisfactory, and in conformity with present accepted standards of good practice. There has been some progress in the use of gas-discharge tubes for industrial lighting, and these are now employed in some iron-foundries and steel-smelting shops. They are also used for special examination processes and for lighting loading bays and factory roadways. In a number of factories of the types mentioned above the colour of the light has been considered advantageous; in this connection the use of this mode of lighting to illuminate the picking and sorting belts in coal screens is of special interest. It is believed that the recently-introduced 250-watt lamp will prove helpful in industrial lighting, especially in cases where the head room is insufficient to accommodate the 400-watt lamp. In one steelworks an installation of these lamps is controlled by photo-electric cells which come into operation on the fading of daylight.

Flood-lighting has also been introduced as a means for providing interior illumination in a large constructional engineering works, and there has been some further progress in the adoption of low-voltage local lighting for certain industrial operations. In older, and more particularly in smaller factories, little progress towards better conditions of lighting appears to have been made during the period under review. The shallow conical reflector is still too much in evidence, and one new installation of some magnitude has been seen in which this was the only type of reflector used. In many modern installations, however, the order of illumination is very much higher than that customary a few years ago. An example of intensive general lighting with close-spaced units is afforded by the works of Joseph Lucas & Company, Limited, Birmingham, where 20 foot-candles are provided, whilst in the adjacent office block semi-corrected artificial daylight (8 foot-candles) is provided throughout.

During the year an investigation undertaken by the Industrial Health Research Board into the effects of lighting on industrial efficiency in the case of "rough" work, in this case tile-pressing, has been completed. The results show that even for work of this kind, which makes little demand upon the visual capacity of the workers, good lighting produces a substantial improvement of efficiency which fully justifies its cost. It appears that an illumination of 3 to 4 foot-candles—a value considerably in excess of that generally employed for work of this kind, is an economic level, though working efficiency may continue to improve with higher values.

Industrial Drives and Running Costs

ESTIMATING ANNUAL FIGURES

MR. R. C. MORTIMER, in the course of an article on "The Modern Industrial Drive and Electrification" in "Fuel Economy Review," refers to the determination of annual running costs. Running expenses for any form of drive, he states, can be divided into the following groups:—(*a*) Capital charges. Under this heading would be included interest on capital invested to provide all plant, buildings and other items essential for the scheme in hand, depreciation, rent, insurance, rates and taxes. (*b*) Fuel or energy costs. (*c*) Wages. (*d*) Repairs and maintenance. (*e*) Miscellaneous extras. Typical items would be lubricating oil, cooling water and feed-water supplies and stores.

Regarding capital charges, a good all-round figure can be taken as 16 per cent. per annum for power plant, but for an electrical purchased power or similar scheme, where no particular part of the factory is set aside for the machinery and insurance rates are less, this figure could be reduced to 13 per cent. Fuel or energy cost can be readily estimated from a knowledge of the average output required, efficiencies of the power unit and boilers (if any) under running conditions, the number of hours worked, calorific value of fuel, and the initial fuel cost per ton or energy cost per unit. It is important not to overlook idle losses where these exist and also to remember that partial factory loading may considerably affect fuel economy. The remaining items will depend almost entirely on the type of equipment under consideration and the correct allocation is often assisted by reference to the corresponding power-plant manufacturer, who will, no doubt, be pleased to advise requirements.

The sum of these items will give a reasonably correct value of the total running costs on which a comparison of schemes can be based. Since capital charges usually form an appreciable part of the annual running expenses, the form of motive power which involves the minimum initial capital expenditure may prove more economical than an alternative proposal with lower fuel costs. In this connection, it should be noted that the smallest investment of money on plant is usually required when purchased electrical power is utilised.

The saving in capital expenditure so effected will mean less money locked up in the non-productive part of the factory, leaving open the possibility of improvements to the actual manufacturing plant. Since it is not illogical to suppose such improvements would be accompanied by increased dividend-paying capacity, then it is apparent that the purchased electrical power scheme could actually have a higher total running cost than an alternative scheme necessitating a greater capital investment, and yet prove the more economical.

Thos. W. Ward, Limited

At meetings of the shareholders of Messrs. Thos. W. Ward, Limited, held at Sheffield recently, the directors' proposal to increase the capital of the company to £2,200,000 by the creation of 350,000 5 per cent. first cumulative preference shares of £1 each was duly sanctioned, and the shares will be offered at par to the public on November 20.

The Spectrographic Analysis of Some Alloys of Aluminium*

By Ernest H. S. van Someren, B.Sc.

A list of the aluminium alloys in commercial production would include considerably more than one hundred names, but analysis of samples shows a great deal of duplication in various countries, and the number of essentially different alloys in common use is probably between 40 and 80. An attempt is made in this Paper to enable users of a spectrograph to find the approximate composition of any unknown aluminium alloy. With such data, supplemented if necessary by the usual physical tests and metallographic examination, either the alloy can be identified or a similar material prepared.

Previous publications on the spectrographic analysis of aluminium are infrequent; the chief contribution is that of A. Schleicher and J. Clermont,† who dealt with titanium, iron and silicon in their first Paper, copper in the second, and zinc in the third. Their method was to photograph the spark spectra, and obtain comparison lines by photographing copper spectra on the same plate with such an exposure as to obtain equality of intensity between specified copper and aluminium lines. The author, with the equipment at his disposal, was not able to reproduce the conditions they laid down, and has consequently not adopted a similar method.

Owing to the instability of the arc between aluminium electrodes, the spark is preferable to the arc for the routine testing of aluminium alloys. With the exception of the alkali metals, no impurity in aluminium is known to be important when present in such a small quantity that it cannot be detected by the spark method. Minute quantities of lithium, sodium and calcium can best be detected by the arc method, and its application to sodium has been developed in the U.S.A. by A. W. Petrey,‡ who uses a small piece of aluminium arced between graphite rods. For this purpose a spectrograph covering the visible range only would be more suitable than one for the ultra-violet the dispersion of which in the visible spectrum is small. A quartz spectrograph will always allow the detection of calcium, and can be used for sodium and lithium if panchromatic plates are used.

The data in this Paper are based on the spectra of 12 commercial alloys, and about 50 synthetic alloys prepared for this work only. The latter were all made from one strip of commercial Norwegian aluminium (99.6 per cent. aluminium) which was selected from material in works production after spectrographic examination of a number of samples. From this metal, with commercial cupro-manganese, commercial magnesium, electrolytic zinc, brass strip, and some soft-iron strip, a few "temper alloys" were made, and these were analysed.

From these alloys and aluminium strip the other alloys were prepared; melts of from 250 to 750 grm. of material were melted in a small gas-fired furnace, using a little charcoal, but no flux, and were cast in flat cakes in a thick iron mould. As many of the alloys as possible were cold-rolled to strip about 3 mm. thick. Spectrographic testing of the material as-cast, and after rolling, produced no evidence of inhomogeneity, except in one or two cases; these samples were discarded.

Five alloy samples were cast and analysed by the Perry Barr Metal Company.

A small quantity of aluminium containing only 0.1 per cent. each of iron and silicon was obtained from Norway, and was used to prepare two alloys containing abnormally low quantities of these impurities.

The composition of the synthetic samples was checked by chemical analysis for about a third of the material used, so that the tables are based partly on analytical results and partly on synthetic figures.

Electrodes of cross-section about 3 × 8 mm. were cut from each sample, and the ends filed to a blunt wedge.

The instrument used was a Hilger medium quartz spectrograph (Model E3) giving a spectrum 150 mm. long from 2200 to 4500 A. (All wave-lengths are in International Angstrom units, usually quoted to the nearest integer.)

A Hilger spark equipment was used, consisting of auto-transformer and transformer, the input being 1.2 amps. at 220 v., 50 p.p.s. A 4-mm. spark gap was used between two electrodes of each sample, situated 200 mm. from the slit, and aligned slightly off the optic axis of the instrument, so that the light passed through less than half the thickness of the prism. A condenser of capacity 0.014 microfarad was in parallel with the spark, and a self-inductance of 0.2 millihenry in series with it. The condition of the spark is best specified by comparison between certain aluminium lines; Al II 2369 should be slightly weaker than Al I 2378, and Al II 2317 should be slightly weaker than Al I 2319. The second line-pair is given because in some alloys containing copper the strong copper line 2370 makes comparisons with the adjacent aluminium line difficult.

The spark was always run for 5 secs. before starting the exposure, during which time its position was checked by a magnified image thrown on a screen by a lens; then an exposure of 20 secs. was given. Ilford thin-film half-tone plates were used, because they are remarkably uniform in sensitiveness over the range 2000—4000; they were developed with metolhydroquinone developer. These plates can be developed, fixed, washed, and dried in half-an-hour. Exposure and development were so adjusted that the group of lines at 2312-2322 was visible, but 2315 was very faint.

The slit-width used was about 0.04 mm., being such that the pair of aluminium lines 3064, 3066 appeared just separate. This wide slit made comparison of relative intensities easier; with a narrow slit some comparisons with diffuse lines are impossible. The plates were examined over opal glass with a lens giving a magnification of about 6 diameters.

The aluminium spectrum is not rich in lines; the characteristic pairs of lines are mostly too strong for comparison with impurity lines, but there are two important groups of faint lines, the wave-lengths of which are tabulated below, stating the strongest and faintest line in each group.

2312.4, 12.8	not resolved	3050.1	
2313.5		3054.7	
2315.0	faintest	3057.2	strongest
2317.5		3059.0	faintest
2319.1		3064.3	
2321.6	strongest	3066.2	

Although there is some doubt as to the allocation of some of these lines between the arc and spark series of aluminium (Al I and Al II), some

TABLE I.

		Aluminium Lines.														
		2204.	2315.	2317.	2319.	2322.	2372.	2378.	2460.	2568.	2652.	2669.	2928.	3050.	3055.	3057.
Copper	2200	2.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All H	2243	—	0.1	0.3	0.4	1.2	—	—	—	—	—	—	—	—	—	—
	2247	—	0.05	0.15	0.2	0.5	—	—	—	—	—	—	—	—	—	—
	2294	—	0.5	1.2	1.5	4.5	—	—	—	—	—	—	—	—	—	—
	2400	—	—	7	9	—	—	—	—	—	—	—	—	—	—	—
	3274	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.07	—
Zinc ..	2558	—	—	—	—	—	—	—	—	5	—	0.5	—	—	—	—
	3076	—	—	—	—	—	—	—	—	—	—	—	—	—	15	—
	3283	—	—	—	—	—	—	—	—	—	—	—	—	H 5	—	H 10
Iron All H ..	2344	—	—	0.22	0.3	0.8	—	—	—	—	—	—	—	—	—	—
	2395	—	—	0.08	0.13	0.36	—	—	—	—	—	—	—	—	—	—
	2663	—	—	—	—	—	—	—	—	—	—	2.0	—	—	—	—
	2740	—	—	—	—	—	—	—	—	—	—	0.16	—	—	—	—
	2743	—	—	—	—	—	—	—	—	—	—	0.6	—	—	—	—
	3020	—	—	—	—	—	—	—	—	—	—	—	—	I ±	—	2
Silicon ..	2435	—	—	—	—	—	H 10 +	—	1.0	—	—	—	—	—	—	—
	2507	—	—	—	—	—	—	—	0.45	—	H 2.8	—	—	—	—	—
	2516	—	—	—	—	—	—	—	0.12	—	H 0.8	—	—	—	—	—
	2519	—	—	—	—	—	—	—	—	—	H 10 ±	—	—	—	—	—
	2881	—	—	—	—	—	—	—	—	—	—	0.12	—	H 0.6	H 0.45	—
Manganese ..	2452	—	—	—	—	—	—	—	H 1 ±	—	—	—	—	—	—	—
	2594	—	—	—	—	—	—	—	—	—	—	H 0.02	—	—	—	—
	2656	—	—	—	—	—	—	—	—	—	—	H 1.2	—	—	—	—
	2673	—	—	—	—	—	—	—	—	—	—	H 0.7	—	—	—	—
	2890	—	—	—	—	—	—	—	—	—	—	—	—	—	—	H 5
	2933	—	—	—	—	—	—	—	—	—	—	—	—	H 0.6	—	H 1.2
	2939	—	—	—	—	—	—	—	—	—	—	—	0.08	H 0.4	H 0.25	—
	2949	—	—	—	—	—	—	—	—	—	—	—	0.05	—	H 0.15	H 0.7
Magnesium ..	2777	—	—	—	—	—	—	—	—	—	H 9	0.6	—	—	—	—
	2783	—	—	—	—	—	—	—	—	—	H 3	0.2	—	—	—	—
	2803	—	—	—	—	—	—	—	—	—	—	H 0.002 ±	—	—	—	—
	2852	—	—	—	—	—	—	—	—	—	H 0.2	—	—	—	—	—
	2937	—	—	—	—	—	—	—	—	—	—	—	—	0.5	0.3	0.9
	3097	—	—	—	—	—	—	—	—	—	—	—	—	H 6	H 3.5	H 9
Nickel ..	2316	—	H 0.05	—	0.15	0.4 N	—	—	—	—	—	—	—	—	—	—
	2438	—	—	—	—	—	—	—	H 1.0	—	—	—	—	—	—	—
	2473	—	—	—	—	—	—	—	H 3 ±	—	—	—	—	—	—	—
	3100	—	—	—	—	—	—	—	—	—	—	—	—	H 2 N	H 1.2	—
Tin	2355	—	—	—	—	—	—	H 2.7	—	—	—	—	—	—	—	—
	2706	—	—	—	—	—	—	—	—	—	—	0.5	—	—	—	—
	2840	—	—	—	—	—	—	—	—	—	—	0.15	—	—	—	—
	3175	—	—	—	—	—	—	—	—	—	—	—	—	—	H 0.6	—
Cadmium ..	2265	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—
	2307	—	I ±	—	—	—	—	—	—	—	—	—	—	—	—	—
	3262	—	—	—	—	—	—	—	—	—	—	—	—	1.2	—	—

* Paper read before the Autumn Meeting of the Institute of Metals at Manchester.

† "Z. anal. Chem.," 1931, 86, 191; 1932, 90, 1, 321.

‡ "Indust. and Eng. Chem." (Analyt. Edn.), 1932, 4, 265.

of them have been used as internal standards for analysis, owing to the absence of other lines of suitable intensity.

It would be desirable to follow the example of certain German investigators and use for quantitative analysis only pairs of aluminium and impurity lines which are homologous, *i.e.*, lines the relative intensity of which is independent of variations in the condition of the spark. For convenience in the examination of the spectra an arbitrary limit of 20 mm. was taken as the maximum distance between lines to be compared. Spectra of many of the samples were photographed with deliberately varied electrical conditions, various dimensions of sample, various times of running of the spark before exposure, and homologous lines were selected when possible; these are marked H in the tables. To avoid large gaps in the tables other pairs of lines have been included. The spark between aluminium electrodes produces more uniform spectra than that between lead or tin electrodes, and this departure from the ideal is justified in practice by its results.

Care has been taken to avoid using lines which coincide with lines due to common alloying constituents in aluminium; where this is inevitable a note is added to the tables.

Table I gives only the percentages of minor constituents at which the pairs of lines referred to are equal; weight percentages are used throughout. An attempt to expand the table by including the concentrations at which the impurity line is less than, and greater than, the aluminium line would lead, in the author's opinion, to an illusion of greater accuracy than is warrantable. When interpolating from these tables, it should be noted that generally, if an impurity line is equal to an aluminium line at x per cent. of the impurity, it will be definitely less at 0.8 x per cent., and equally definitely greater at 1.4 x per cent. (1.3 x per cent. if both lines are very faint). This unsymmetrical nature of the change in relative intensity has been observed by the author when making large numbers of observations on samples of fairly similar composition, and should be borne in mind when interpolating from the table. It is supported by the fact that the general shape of curves connecting the relative intensity of a pair of lines with the concentration of an impurity (as measured with a microphotometer or wedge sector) is concave towards the concentration axis.

The percentages for equality quoted in the table do not always correspond with the analysis of an individual sample, but each is the result of a number of observations on the spectra of a few appropriate samples, each photographed at least four times. This method of formulating tables introduces a possible error, which must be added to the uncertainty resulting from occasional reliance on synthetic figures for the composition of samples. The total uncertainty can be best expressed by stating the result of a spectrographic analysis in the form: the concentration of the impurity M lies between m per cent. and 2 m per cent. In routine analysis of aluminium samples by this method accuracy will be increased by experience, and should, after a few months, be comparable with that of ordinary chemical analysis as practised in an industrial laboratory except for concentrations of more than 2 per cent. of alloying constituents.

Although the proportion of alloying constituents in many aluminium alloys is sufficient to make the aluminium lines in the spectrum fainter than in that of ordinary aluminium (with the same exposure), the lines due to the lesser impurities are also apparently fainter; consequently no appreciable modifications in the Tables appear to be necessary from this cause. This source of error has, however, not been completely explored, and is likely to be significant in some aluminium-zinc casting alloys.

The same aluminium lines are used for comparison with lines of different impurities, and Table I shows certain regularities in the percentages at which equality occurs. This regularity might be made use of in extending the Table to other percentages of impurities—for cadmium, for example. Unfortunately, a change in the author's occupation prevents him from checking the accuracy obtainable in this way.

Certain lines mentioned in Table I are sometimes masked by lines due to other metals, and then may not be used for intensity comparisons. These are set out in the first column of Table II; in the second column follows the symbol for the metal which interferes; and the last

TABLE II.

I.	II.	III.	IV.
Al 2928	Mg	2937	2928
Al 2669	Cr	2677	2652
Al 2322	Cd	2313	2313.5
Al 2322	Ni	2316	2319
Al 3050	Ni	3100	3055
Si 2881	Cd	2981	2928
Zn 3076	Ti	3087	3055

two columns specify a line due to that metal, and an aluminium line. If the line in column III is stronger than the line in column IV, then the line mentioned in column I must not be used. Usually comparison may be made by the help of an adjacent aluminium spectrum so exposed that its fainter lines are equal to the same lines in the spectrum of the sample. This is certain to be necessary in the analysis of aluminium containing nickel, where the comparisons marked N in Table I can never be made directly in the same spectrum, on account of other nickel lines.

In Table III are set out the lower limits for the detection of various elements in aluminium under the conditions already laid down. Two lines are given for each element, in order of sensitiveness. For antimony the only possible confirmatory lines are masked by iron and silicon; for bismuth no second line is likely to occur, and a narrower slit than usual must be used on account of the line Al 3066. For the detection of tin, lead, bismuth, and antimony the arc method is at least ten times more sensitive than the spark.

TABLE III.

Element.	Lower limit per cent.	Lines used.	
Copper	less than 0.01	3247	3274
Zinc	0.1	3345	3303
Iron	less than 0.02	2382	2740
Silicon	less than 0.02	2516	2881
Manganese ..	0.004	2594	2606
Magnesium ..	less than 0.002	2803	2852
Nickel	0.025	2316	3414
Tin	0.1	2840	2863
Cadmium ..	0.01	2265	2288
Lead	0.1	2833	3684
Antimony ..	0.2	2311.5	
Chromium ..	0.1	2836	2843
Titanium ..	0.03	3350	3361
Calcium ..	less than 0.01	3934	3968
Bismuth ..	0.1	3068	

Note to Table III.—Pb 2833 equals Al 2669 at 0.4 per cent.; Sb 2311 equals Al 2315 at 0.3 per cent.

Acknowledgments

The thanks of the author are due to the management of the Nordiske Kabel- og Traadfabrikker A/S., Copenhagen, for permission to publish this Paper, the result of experimental work carried out in the laboratory of their rolling mill.

Thanks are also rendered to Ingenior Henning Hansen, who analysed most of the standard samples, to the Superintendent of Research of I.C.I. Metals, Limited, Birmingham, for two analyses, and to the chief chemist of the Perry Barr Metal Company (Birmingham) for the provision of five analysed samples.

THE VULCAN FOUNDRY, LIMITED, has secured an order for sixteen steam locomotives and tenders for the Canton and Hankow Railway of China, to the order of the Chinese Purchasing Commission.

Permeability of Refractories at High Temperatures

In the summary of a Paper entitled "The Permeability of Ceramic Bodies to Gases at High Temperatures," presented by DR. P. BREMOND before the Ceramic Society, in London, the author pointed out that some investigators concluded that for refractories and other ceramic bodies at room temperature the law of permeability agreed with Graham's law of diffusion—that flow was inversely proportional to square root of density—but this was not true of gaseous permeability at high temperature. In the latter case, Poiseuille's viscosity law is nearer, but by no means accurate. Regarding permeable bodies "as impermeable matter crossed by numerous and more or less thin capillaries," the author classified the capillaries into three chief categories: (1) cracks; (2) capillaries having a diameter wider than the "mean free path" of the molecules; (3) capillaries having a diameter smaller than or of the same order of length as the mean free path. The second of these classes comprised "coarse" bodies, and the third consisted of fine bodies.

Coarse bodies were very permeable at room temperature and "corked" at high temperatures. This type of flow was approximately encountered with bodies of coarse structure and not too thick, as saggar walls, silica bricks, etc. The rate of flow decreased very rapidly with increase of temperature. But it must be remembered that permeable ceramic bodies had a mixture of coarse and fine structures. The ceramic bodies with fine structure included earthenware, burned clay, hard porcelain. At room temperatures, gaseous flow through such bodies was inversely proportional to the square root of the absolute density of the gas (that was, in accordance with Graham's law), all other conditions being equal. At high temperatures that was not the case.

The author concluded that the calculation of a flow through a fine body at high temperature was impossible, because it depended on adsorption, which was variable from one material to another. Whilst the flow of gas through coarse bodies was not selective, the flow through fine bodies was selective—the light gases crossing the fine structures more easily than the heavy ones (which did not happen in coarse bodies). These differences of velocity might make a difference of gas pressures in permeable bodies, which explained some reactions. When light gases, such as hydrogen and hydrocarbons, were in contact with fine-structured bodies, they passed rapidly into them, gases being thus adsorbed by the walls of the capillaries, and this was the starting point of physico-chemical catalytic reactions between gases and solids. Such reactions might occur in all sorts of furnaces, including gas retorts and chambers, blast furnaces, etc.

The author's experiment proved that colloidal matter (raw or calcined), such as clays, china clays, colloidal silica or alumina, ferric hydrate, carbon, being of very fine structure, are practically the only ones which are affected by reducing gases or hydrocarbons such as methane (CH_4), ethylene (C_2H_4)—and, of course, coal gas—at high temperature, with the immediate breaking down of hydrocarbons and formation of carbon deposits in the body. Conversely, under the same conditions, crystalline materials, such as quartz, felspar, ground raw enamels, being of coarse structure, were affected very little or not at all, and no deposit of carbon took place

THE CONSTRUCTION PROGRAMME of the Showa Steelworks, Japan, which were expected to start steelmaking early next year, has not progressed as expected, and the start of operations has now been postponed to the autumn of 1935. The 100-ton furnace is now scheduled to start production in October, 1935, and the rolling mills in the following December.

XUM

This photograph gives you some idea of the compact lines of the unit. There are no external pipes; the machine is entirely self-contained

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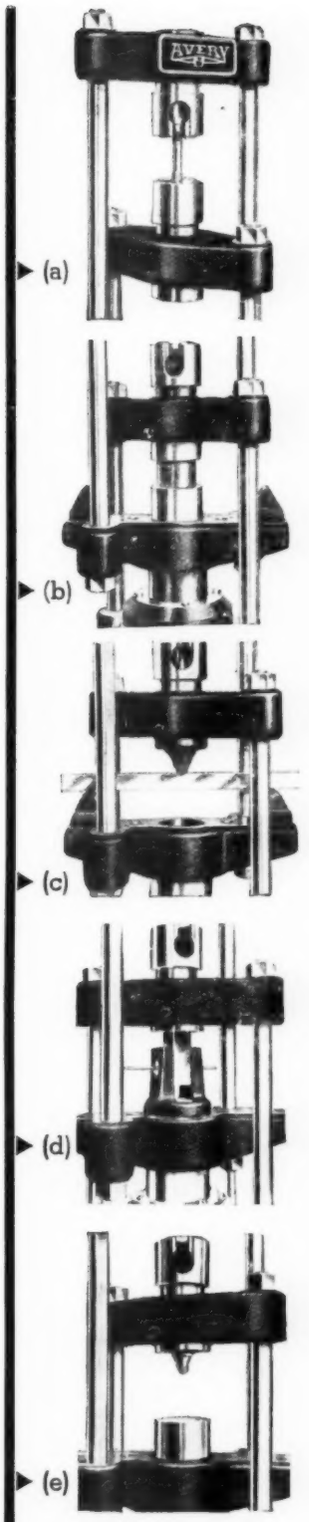

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This Week's News in Brief

Trade Talk

IT IS OFFICIALLY ANNOUNCED that Messrs. Fleming & Ferguson have secured contracts to build two dredgers for India.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Springburn, Glasgow, have received an order to build six passenger locomotives and bogie tenders for the El Kantara-Haifa section of the Palestine railways.

MESSRS. COLVILLES, LIMITED, have granted ground attached to their works at Glengarnock for use as allotments for the unemployed workers. An allotments association is being formed in Beith, and the County Council have also agreed to provide ground.

CONTRIBUTIONS HAVE BEEN MADE to Glasgow and West of Scotland infirmaries and other charitable institutions by employees of Messrs. G. & J. Weir, Limited, Cathcart, Glasgow, who have given £706; and of Messrs. Andrew Barclay & Sons, Limited, Caledonia Works, Kilmarnock, who have contributed £50.

MESSRS. DAVID & WILLIAM HENDERSON, LIMITED, Partick, Glasgow, have launched the steel-screw cargo steamer "Martaban," which has been built to the order of Messrs. P. Henderson & Company, Limited, Glasgow. The vessel has been built to the British Corporation's highest class, and is 385 ft. in length, with gross tonnage of 4,200.

MESSRS. ARDROSSAN DOCKYARD, LIMITED, have received an order from Messrs. Lynch Bros., London, for five steel lighters for shipment abroad. The vessels have a length of 156 ft., and carry 240 tons of cargo on a draft of 3 ft. The boats will, after erection in the builders' yard, be dismantled for shipment and re-erection in the Near East.

THE FORD MOTOR COMPANY OF CANADA has announced that it will construct an electric-furnace foundry adjoining its East Windsor, Ontario, plant, where crankshafts will be cast for the V-eight Canadian-built cars. This will be the first major expenditure of the Ford Company of Canada for new construction work since the early days of the depression.

CONTINUITY OF EMPLOYMENT is assured for 200 workers at Messrs. Robert Brown & Son, Limited, fireclay works, at Fergusliе, Paisley, as a result of an announcement that the Associated Fireclay Companies, Limited, London, will take over the Paisley works as a branch of the company. Messrs. Brown's business was established in 1840, but its future has for some time been uncertain owing to trade depression.

MANY SHIPBUILDING ORDERS are expected on the Clyde before the end of the year. Negotiations are now in progress, and will be completed before Christmas. A well-known industrialist, in an interview with our representative, said: "We are preparing for a big output of iron and steel for shipbuilding and have been advised to shape our plans accordingly. Large quantities of steel are wanted for the new £2,000,000 cruiser to be built at Clydebank, which will probably be produced in Lanarkshire, as was the steel for the "Queen Mary."

MESSRS. ALEXANDER HALL & COMPANY, LIMITED, Footdee shipyard, Aberdeen, have received two orders, one for the building of a tugboat and one for a steam pilot boat. The former, which is to be built for the Gamecock Steam Towing Company, Limited, London, will be similar to those previously built by Messrs. Hall for the same owners. It will be equipped with salvage gear, patent balanced rudder, fire-fighting appliances, and electric light, including searchlight. The pilot boat is for the Blyth Pilot Service and will be steam driven.

MESSRS. A. P. NEWALL & COMPANY, LIMITED, Woodside Works, Possilpark, Glasgow, have commenced the erection of new works at Balmore Road for the manufacture of special steels and wire drawing. The firm have for long specialised in the production of bolts and rivets. The new buildings will be of steel-framed construction erected by Messrs. William Bain & Company, Limited, Lochrin Iron Works, Coatbridge.

AMONG RECENT ORDERS, Messrs. J. Browett-Lindley (1931), Limited, Letchworth, have received a contract from Messrs. Glynns Lydenburg, Limited, for the supply of a two-crank, two-stage, double-acting air compressor driven by a 200-h.p. induction motor, the capacity being 60,000 cub. ft. free air per hour, compressed to 80/100 lbs. per sq. in. This machine is to be installed in a South African mine, and will be an exact duplicate of an equipment supplied in 1930. A further recent contract was for two 500-b.h.p. back-pressure steam engines for the Argentine.

IT IS CONFIRMED by Mr. Chas. U. Peat, M.P. for Darlington, that "an important group of business men prominent in the English steel industry" is behind a project for the establishment of a new works in the North of England—probably at Darlington—for the production of cold-rolled steel. Search is now being made for a suitable site and it is understood that £500,000 is available for the erection of the plant, which is intended to produce steel sheets in the form of motor-car bodies, window frames, doors and partitions and steel office furniture. "Motor-car manufacturers," says Mr. Peat, "have already been approached and have expressed their intention of placing large orders with the new company."

THE INDIAN STEEL INDUSTRY PROTECTION BILL has given an impetus to the establishment of new steelworks in India, for which Japanese capital has been readily forthcoming. A new steelworks is being erected at Belur, near Calcutta, with the participation of Japanese capital. Some of the steelworks plant is being supplied by Japan, and the electrical machinery by Great Britain and the United States. The new works are to produce iron and steel bars, steel rails, screws, and wire products. The participation of Japanese financiers and industrialists in this venture is regarded with favour in India, as it is expected to reduce Japanese competition. A smaller steelworks with Indian and Japanese capital is also to be erected near Bombay.

THE MOTHERWELL IRON & STEEL COMPANY, LIMITED, have posted notices of termination of contracts with their employees and the closing down of the works. The works, which have been in operation for many years, have been fairly busy for some time past, and have experienced a much brisker working year than last. The long financial strain, however, which seemed on the point of being overcome, has necessitated the posting of the notice, which has come as a surprise to the workers. The situation is, however, not to be regarded as altogether hopeless, and it is thought possible than some reconstructive measures may be employed to render unnecessary the abandonment of the works, which only two or three years ago were brought up to date by the erection of new and modern plant.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

General Cable Manufacturing Company, Limited, 52, Russell Square, London, W.C.1.—Capital £150,000. Cable manufacturers and agents. Directors: C. W. R. Pantlin, E. G. Bisseker, Sir Joseph W. L. Napier and J. Wright.

Metropolitan-Cammell Carriage & Wagon Company, Limited.—Capital £1,000,308. To acquire the Metropolitan-Cammell Carriage, Wagon & Finance Company, Limited (in liquidation); to enter into an agreement with the said company and the liquidator thereof, Vickers, Limited, and Cammell Laird & Company, Limited, and to carry on the business of manufacturers of and dealers in engines, carriages and wagons. Directors: Col. J. B. Neilson, Sir Charles W. Craven and W. L. Hichens.

Contracts Open

Belfast, November 26.—The Harbour Commissioners invite tenders for the supply of iron castings, malleable iron and steel, bolts and nuts. Mr. M. J. Watkins, general manager and secretary, Harbour Office, Belfast.

Margate, November 19.—3½ miles of cast-iron pipes, 3-in. to 12-in. dia., with various cast-iron specials, for the Town Council. Mr. E. A. Borg, borough engineer and surveyor, 40, Grosvenor Place, Margate.

Personal

MR. JAMES R. ALLAN, vice-chairman and formerly managing director of Messrs. David Colville & Sons, Limited, has secured a seat on Prestwick Town Council.

CAPTAIN H. J. KENNARD, R.N., retired, managing director of the Falkirk Iron Company, Limited, who is also a judge in the Burgh of Falkirk, has been appointed Convener of the Falkirk Town Council Gas Committee.

THE EMPLOYEES OF Messrs. Mitchell Russell, Chattan Ironworks, Bonnybridge, assembled last week to honour one of their colleagues, Miss Jessie Parker, on the occasion of her approaching marriage. Mr. John McGregor made the presentation of an easy chair and three leather-covered chairs.

MR. ROBERT BALLANTINE, who has been foundry manager to Messrs. Thos. White & Sons, Limited, Laighpark Works, Paisley, for about six years, has resigned consequent upon his appointment as foundry manager to the Fullwood Foundry Company, Mossend, in succession to the late Mr. Angus C. Miller.

MR. ALEXANDER MARSHALL has been appointed foundry manager to Messrs. Thos. White & Sons, Limited, in succession to Mr Ballantine. Mr. Marshall has had many years' experience in a number of Scottish works, including the Singer Company, Messrs. Mavor & Coulson, Limited, and Messrs. Alexander Stephen & Sons, Limited. He has also for some years been a teacher of foundry work and patternmaking for the Glasgow Corporation.

THE COUNCIL of the Iron and Steel Institute have elected as Vice-Presidents Dr. W. H. Hatfield, D.Met., Director of Research at the Brown-Firth Research Laboratories, and director of Messrs. Thomas Firth & John Brown, Limited, who has been a member of the Council since 1927, and Sir William J. Larke, K.B.E., Director of the British Iron and Steel Federation, who has been an hon. member of the Council since 1927. Lieut.-Col. Sir Maurice H. L. Bell, Bt., C.M.G., director of Messrs. Dorman, Long & Company, Limited, was elected an Honorary Vice-President. He has been a member of the Council since 1927.

DR. HORMANN VON SCHRENK, Senior Vice-President of the American Society for Testing Materials, has been elected to the office of President. This action was taken by the Executive Committee to fill the vacancy caused by the death of Mr. W. H. Bassett, which occurred on July 21, soon after he took office as head of the Society. The vacancy created by Dr. von Schrenk's election was filled by the appointment of Mr. H. S. Vassar, as Senior Vice-President, Mr. Vassar having been elected a Vice-President last June. Mr. A. C. Fieldner, chief engineer, Experiment Stations Division, U.S. Bureau of Mines, Washington, D.C., has been elected Junior Vice-President.

Obituary

WE REGRET TO RECORD the death of Mr. J. F. Berry, of Lightcliffe, who succeeded his father as proprietor of the firm of John Berry, ironfoundry, New Bank, Halifax. Mr. Berry was 60 years of age, and had been ill since August.

Forthcoming Events

Institute of British Foundrymen

NOVEMBER 23 AND 24.

London and East Midlands Branches:—Joint conference in London. *Friday*: (1) Visit to works of the Ford Motor Company, Limited; (2) informal dinner. *Saturday*: (1) "Some Experiences in the Manufacture of High-Grade and Alloy Castings," by P. A. Russell, B.Sc.; (2) "Enamelling of Cast Iron," by B. B. Kent. Papers to be read at the Charing Cross Hotel, W.C.2, at 10 a.m.

The Institute of Vitreous Enamellers

NOVEMBER 21.

Northern Section:—"Costing for Vitreous Enamelling," Paper by W. H. Whittle, at the Queen's Hotel, Piccadilly, Manchester, at 7.30 p.m.

NOVEMBER 28.

Midland Section:—"Costing for Vitreous Enamelling," Paper by W. Todd, at the Chamber of Commerce, New Street, Birmingham, at 7.30 p.m.

NOVEMBER 29.

Southern Section:—"Costing for Vitreous Enamelling," Paper by J. H. Coupe, at British Industries House, Marble Arch, London, W.1, at 8 p.m.

WM. CUMMING & CO. LTD.

The Leading Manufacturers!
The Oldest Established!!
The Most Reliable!!!

Ironfounders' Facings Manufacturers and General Foundry Furnishers,

Kelvinvale Mills, Maryhill, GLASGOW

Branches at Falkirk, Chesterfield, Deepfields and Middlesbrough

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SUPERFINE COAL DUST

SUPERLATIVELY REGULAR IN GRIST.
SUPERIOR IN QUALITY.
SEVEN GRISTS STANDARDISED.
ONE QUALITY OF COAL THROUGHOUT.

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INGOT MOULD BLACKING

THE BEST ON THE MARKET.
MANUFACTURED BY THE NEW PROCESS.

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BRITISH PLUMBAGOS

AT LOW PRICES.
IMPORTED DIRECT.
NO CONTINENTAL ADULTERATION.

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CUMMING FURNACE

USERS OF THE NEW "CUMMING" FURNACE ARE INCREASING WEEK BY WEEK.

CORE COMPOUNDS, PARTINGS, CUMMINGSTONE, REQUISITES, BLACKINGS for every PURPOSE

ALL OUR OWN MAKE

Raw Material Markets

The continuance of the heavy demand for pig-iron over a long period has engendered a feeling of quiet confidence in the market, and producers are not hesitating to put in hand schemes for extension and reconstruction. The slightly bigger export demand of late is also a good sign. Conditions in the steel trade vary from one section to another, but the general position is quite promising.

Pig-Iron

MIDDLESBROUGH.—The demand for Cleveland foundry iron continues to exceed the output, and, although fair tonnages of iron are still in stock at the works, these are not inexhaustible and an extension of the output may have to be considered if the present demand continues. Quotations to home consumers are unchanged, No. 3 Cleveland G.M.B. being 67s. 6d. per ton delivered Middlesbrough, 69s. 6d. delivered North-East Coast, 67s. 3d. delivered Falkirk, and 70s. 3d. delivered Glasgow. For other qualities there are the usual differences, namely, 2s. 6d. per ton premium for No. 1 foundry and 1s. discount on No. 4 foundry and No. 4 forge.

The demand for East Coast hematite is still expanding, especially from the local steelworks, Sheffield and the Midlands. Some producers in this area are booked as far ahead as they care to go at present prices, and have advanced quotations for export by 1s. 6d. per ton. No. 1 East Coast hematite is now quoted round about 62s. 6d. per ton f.o.b., and moreover that figure has been paid. Fixed minimum prices of No. 1 East Coast hematite to home consumers are 69s. per ton delivered Middlesbrough, 71s. per ton delivered Durham and Northumberland, 75s. delivered Scotland, 76s. delivered Lancashire, 75s. to 78s. delivered Yorkshire, and 79s. delivered Birmingham.

LANCASHIRE.—A steady flow of Midlands iron to Lancashire foundries is taking place. For delivery to users in the Lancashire price zone, Midland brands of No. 3—Derbyshire and Staffordshire—and also North-East Coast iron and Lancashire makes equal to Derbyshire, are all quoted on the basis of 74s. per ton, with Northants at 72s. 6d., Scottish foundry at about 82s. 6d., East Coast hematite iron at from 75s. to 76s. per ton, according to grade, and West Coast material at about 78s. 6d.

MIDLANDS.—There has been a slight improvement in the demand for foundry iron, attributed to a recovery in the light-castings trade, and the output of iron is fully taken up. There is no difficulty about delivery, as the furnaces have good stocks. No changes in prices have been made. The minimum controlled figures delivered Birmingham and Black Country stations, and subject to rebate for large users, are 67s. 6d. for Northants No. 3 and 71s. per ton for Derbyshire, Lincolnshire and North Staffordshire No. 3. With regard to iron for the engineering and motor trades, prices continue to vary to a considerable degree. Low-phosphorus brands are quoted at between 85s. and 87s. 6d., including Scottish No. 3 at 85s., medium-phosphorus iron at 72s. 6d. to 80s., and special refined iron for high-duty work at £5 7s. 6d. to £6 10s., delivered this district.

SCOTLAND.—The market in foundry iron remains steady. There is no change in the official price of Scottish foundry iron at 70s. f.o.t. furnaces for No. 3, with 2s. 6d. extra for No. 1. There is not much demand for the latter. The position in the light-castings trade, which had eased off slightly, is again better, and all works are fully employed. There is no change in the prices they are being asked to pay for Cleveland iron, viz., 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Falkirk for No. 3, with No. 4 foundry 1s. per ton less.

Coke

The situation in the foundry-coke market is unchanged, most consumers being already contracted over the winter months. Quotations for delivery in the Birmingham area are as follow:—Best Durham foundry, 36s. to 40s.; Welsh coke, 35s. to 45s.; Scottish low-ash coke, about 41s. per ton, delivered Midland points.

Steel

The slight increase in activity noticed recently in the steel markets has increased rather than diminished. It is not unusual for the demand to strengthen at this season before the end-of-the-year slackness makes itself felt; but indications point to the works maintaining a good rate of activity for some months to come. The position in the semi-finished steel section of the market has also developed some satisfactory features. Many of the large consumers have covered their needs for some time ahead and others have been working on stocks. This week, however, buying has been on an improved scale. Most of the works producing finished steel have taken sufficient orders lately to ensure a good rate of production well into the New Year. Although by far the greater part of the business transacted recently has been with home users, the export trade appears to be improving.

Scrap

There is a better demand for scrap iron in the Cleveland area, up to 53s. 6d. being paid for ordinary heavy metal and 55s. to 56s. 6d. per ton for machinery metal. There is a steady demand for cast-iron scrap in the Midlands, at unchanged prices. In South Wales there is a fair demand for heavy cast iron in large pieces and furnace sizes at 48s. 6d. to 50s., but light metal and machinery metal remain quiet at 41s. 6d. to 42s. 6d. and 52s. 6d. to 55s. per ton, respectively. In Scotland, ironfoundries are open to buy heavy machinery scrap at 55s. to 56s., with ordinary cast iron at 52s. per ton.

Metals

Copper.—Although the copper market is somewhat firmer, confidence has not yet been fully restored. Quotations still have an erratic tendency and are influenced more by rumours regarding the meeting of producers in New York than by fluctuations in the actual demand from users. Copper consumption in this country is said to be developing favourably, but reports from the Continent are much less satisfactory.

Daily market prices:—

Cash.—Thursday, £27 5s. to £27 6s. 3d.; Friday, £27 2s. 6d to £27 3s. 9d.; Monday, £27 6s. 3d. to £27 7s. 6d.; Tuesday, £27 5s. to £27 6s. 3d.; Wednesday, £27 10s. to £27 12s. 6d.

Three Months.—Thursday, £27 11s. 3d. to £27 12s. 6d.; Friday, £27 8s. 9d. to £27 10s.; Monday, £27 12s. 6d. to £27 13s. 9d.; Tuesday, £27 12s. 6d. to £27 13s. 9d.; Wednesday, £27 17s. 6d. to £27 18s. 9d.

Tin.—The value of this metal on the London market has remained fairly stable, largely as the result of support given by the "pool." The latter group has, however, been forced to make very large purchases in order to hold up prices, and it is rumoured that a cut in production will be proposed at the next meeting of the International Tin Committee.

Messrs. Henry Gardner report that "the tightness of the near position has disappeared, at least temporarily, and at one time a contango of 15s. was paid. It is, however, probable that a backwardation will again obtain not later than the beginning of the New Year. Consumption at present does not justify the existing high level of prices, but, as the market is so firmly controlled, a further advance is quite probable."

Price fluctuations:—

Cash.—Thursday, £228 7s. 6d. to £228 10s.; Friday, £229 2s. 6d. to £229 5s.; Monday, £228 10s. to £228 12s. 6d.; Tuesday, £228 7s. 6d. to £228 10s.; Wednesday, £228 5s. to £228 10s.

Three Months.—Thursday, £228 15s. to £229; Friday, £229 5s. to £229 7s. 6d.; Monday, £228 15s. to £228 17s. 6d.; Tuesday, £228 10s. to £228 15s.; Wednesday, £228 12s. 6d. to £228 15s.

Spelter.—The outlook in this market is very obscure at the moment, and prices have weakened correspondingly. The International Zinc Cartel, which controls production, is to expire at the end of the year, under the existing agreement. So far, negotiations for its renewal have not been attended with any success.

Day-to-day quotations:—

Ordinary.—Thursday, £12 3s. 9d.; Friday, £11 17s. 6d.; Monday, £11 17s. 6d.; Tuesday, £11 18s. 9d.; Wednesday, £11 17s. 6d.

Lead.—This market has been steady, but on balance the tendency has been weaker. Although there has not been much change in the volume of consumption in this country, the demand from those branches of the industry which supply the building trade has been less active. This is probably only a natural result of the seasonal trend, and is being counteracted to some extent by the improvement in demand from the cablemakers, which is being well maintained.

Price fluctuations have been as follow:—

Soft Foreign (Prompt).—Thursday, £10 5s.; Friday, £10 3s. 9d.; Monday, £10 5s.; Tuesday, £10 5s.; Wednesday, £10 6s. 3d.

Iron and Steel Institute

CO-OPERATION WITH ALLIED SOCIETIES

The Iron and Steel Institute has completed details for extending arrangements for mutual co-operation existing between the Institute and the following bodies:—(1) Sheffield Metallurgical Association; (2) Sheffield Society of Engineers and Metallurgists; (3) Lincolnshire Iron and Steel Institute; (4) Staffordshire Iron and Steel Institute; (5) West of Scotland Iron and Steel Institute; and (6) Cleveland Institution of Engineers. It is hoped also to extend the same facilities to the Manchester Metallurgical Society.

Briefly, the arrangements are as follow:—

The Iron and Steel Institute has agreed to extend the maximum age of associate membership of the Iron and Steel Institute from 24 years of age, as previously fixed, to 30 years of age in the case of associate members who are also members of any one of these societies. Associate members of the Iron and Steel Institute are entitled to receive the "Journal" and other publications free of charge, and to enjoy all other facilities extended to members, including the use of the loan library, but are not entitled to a vote at general meetings. The subscription is one guinea a year (instead of three guineas for full membership) and the payment of an entrance fee (two guineas in the case of full membership) is waived; no transfer fee becomes payable on transference to full membership. (This arrangement does not apply to members of any allied society who are under 30 years of age, but who are already full members of the Iron and Steel Institute.)

The Council of the Iron and Steel Institute has agreed to supply each year to the societies, for presentation and discussion at meetings, certain Papers which have been presented at the general meetings of the Iron and Steel Institute.

It is hoped by those means usefully to extend the existing co-operation between the Iron and Steel Institute and allied societies, and particularly to encourage the study of problems connected with the manufacture and metallurgy of iron and steel, especially among younger members. Members are reminded of the advantages to be obtained from membership of the Iron and Steel Institute.

The secretary of the Iron and Steel Institute, 28, Victoria Street, London, S.W.1, or the secretaries of the various societies concerned, will be pleased to supply further information.

Flying to Manchester

Most of the London members of the Council of The Institute of Vitreous Enamellers are flying to Manchester for their meeting scheduled to take place in that city on November 21. The plane, which is a three-engined eight-seater Comet, will leave Croydon at 1.30 and alight on the return hop before midnight. The cost is about £5 per person. There are still three seats vacant and anyone wishing to join the party should write immediately to Mr. B. B. Kent, Sterling Manufacturing Company, Davis Street, Cubitt Town, London, E.14.

XUM

For LARGE DECORATIVE CASTINGS

ALUMINIUM AND LIGHT ALLOYS

The BRITISH ALUMINIUM CO. Ltd.

HEAD OFFICE: ADELAIDE HOUSE, KING WILLIAM ST., LONDON, E.C.4.
TELEPHONE: MANSION HOUSE 5561 & 8074 (5 LINES) TELEGRAMS: CRYOLITE, BILGATE, LONDON.

One of five castings, in No. 40B aluminium alloy.

The largest casting is 8 ft. in diameter and has an average thickness of ½ in. and weighs 250 lbs.

● LONDON WAREHOUSE: 25-29, Pancras Road, N.W.1.
● BIRMINGHAM: 2, Lawley Street.
● MANCHESTER: 274, Deansgate.
● LEEDS: 66, Kirkstall Road.
● NEWCASTLE-ON-TYNE: Milburn House.
● GLASGOW: 113, West Regent Street.

The BRITISH ALUMINIUM COMPANY, Ltd.

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BARROW IRON

OPEN HEARTH REFINED
REFINED CUPOLA
WEST COAST HÆMATITE

Also SEMI-PHOSPHORIC
for Motor Cylinders, Valve Bodies, Steam and Hydraulic Castings, Etc.

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THE BARROW HÆMATITE STEEL CO., LTD., BARROW-IN-FURNESS. LANCS.

RAW MATERIALS—PRICE LIST

(Wednesday, November 14, 1934)

COPPER

	£	s.	d.
Standard cash	27	10	0
Three months	27	17	6
Electrolytic	30	15	0
Tough	29	10	0
Best selected	30	0	0
Sheets	58	0	0
India	40	15	0
Wire bars	31	0	0
Ingot bars	31	0	0
H.C. wire rods	33	10	0
Off. av. cash, October	26	15	9 3/16
Do., 3 mths., October	27	1	8 3/16
Do., Sttlmnt., October	26	15	11 7/16
Do., Electro, October	29	17	6
Do., B.S., October	29	15	10
Do., wire bars, October	30	5	5 5/16
Solid drawn tubes			9½d.
Brazed tubes			9½d.
Wire			6d.

BRASS

Solid drawn tubes	8¾d.
Brazed tubes	10¾d.
Rods, drawn	8¼d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7d.
Wire	7¼d.
Rolled metal	6¾d.
Yellow metal rods	4¼d.
Do. 4 × 4 Squares	5¼d.
Do. 4 × 3 Sheets	5½d.

TIN

	£	s.	d.
Standard cash	228	5	0
Three months	228	12	6
English	228	10	0
Bars	230	12	6
Straits	228	15	0
Australian (nom.)			—
Eastern	230	0	0
Banca	229	17	6
Off. av. cash, October	230	13	7 15/16
Do., 3 mths., October	228	16	9 13/16
Do., Sttlmt., October	230	13	8 15/16

SPELTER

	£	s.	d.
Ordinary	11	17	6
Remelted	13	0	0
Hard	10	5	0
Electro 99.9	14	12	6
English	13	2	6
India	11	15	0
Zinc dust	17	0	0
Zinc ashes	3	0	0
Off. aver., October	12	5	8 1/16
Aver. spot, October	12	4	4 3/16

LEAD

	£	s.	d.
Soft foreign ppt.	10	6	3
Empire (nom.)	11	7	6
English	12	10	0
Off. average, October	10	9	1 13/16
Average spot, October	10	7	2 3/16

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	10	0
Do., V.M. ex whse.	22	15	0
Rods	26	15	0

ANTIMONY

	£	s.	d.
English	60	0	0
Chinese, ex-whse.	56	0	0
Crude		—	

QUICKSILVER

	£	s.	d.	£	s.	d.
Quicksilver	11	2	6 to	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£13 0 0
75%	£18 7 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	5/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£29 15 0
4/6% car.	£23 0 0
6/8% car.	£21 12 6
8/10% car.	£21 12 6
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 15 0
Max. 0.70% car.	£42 0 0
70%, carbon-free	10d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/3 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	2	15	0 to	2	16	0
Bundled shrngs.				2	7	6
Mixed iron and steel	2	10	0 to	2	12	0
Heavy cast iron	2	8	6 to	2	10	0
Good machinery	2	12	6 to	2	15	0
Cleveland—						
Heavy steel	2	10	0 to	2	12	6
Steel turnings				1	15	0
Cast-iron borings				1	5	0
Heavy forge				2	10	0
W.I. piling scrap				2	5	0
Cast-iron scrap	2	12	6 to	2	16	3
Midlands—						
Light cast-iron scrap				2	7	6
Heavy wrought iron				3	0	0
Steel turnings, f.o.r.	1	12	6 to	1	13	6
Scotland—						
Heavy steel				2	10	0
Ordinary cast iron				2	12	0
Engineers' turnings				1	19	6
Cast-iron borings				1	17	6
Wrought-iron piling	2	10	0 to	2	11	3
Heavy machinery	2	15	0 to	2	16	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	24	0	0
Brass	16	10	0
Lead (less usual draft)	10	0	0
Tea lead	7	0	0
Zinc	9	0	0
New aluminium cuttings	66	0	0
Braziery copper	19	0	0
Gunmetal	23	0	0
Hollow pewter	150	0	0
Shaped black pewter	112	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	69/-
Hematite M/Nos.	68/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
E.C. hematite	81/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	12	6 to	9	15	0
Nut and bolt iron	7	10	0 to	8	0	0
Hoops	10	10	0 and up.			
Marked bars (Staffs) f.o.t.			12	0	0	
Gas strip	10	10	0 and up.			
Bolts and nuts, ¾ in. × 4 in.	14	0	0			
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	0	0 to	8	10	0
Chequer plts.			10	7	6	
Angles			8	7	6	
Tees			9	7	6	
Joists			8	15	0	
Rounds and squares, 3 in. to 5½ in.			9	7	6	
Rounds under 3 in. to ⅜ in. (Untested)			8	12	0	
Flats—8 in. wide and over			8	12	6	
,, under 8 in. and over 5 in.			8	17	6	
Rails, heavy	8	5	0 to	8	10	0
Fishplates	12	5	0 to	12	10	0
Hoops (Staffs)			9	7	0	
Black sheets, 24g. (4-t. lots)			10	10	0	
Galv. cor. shts. (,,)			13	0	0	
Galv. flat shts. (,,)			13	10	0	
Galv. fencing wire, 8g. plain			14	10	0	
Billets, soft	5	10	0 and up.			
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	2	6 to	5	10	0
Tin bars	5	2	6 to	5	7	6

PHOSPHOR BRONZE

	Per lb. basis
Strip	9d.
Sheet to 10 w.g.	10d.
Wire	11¼d.
Rods	10d.
Tubes	13d.
Castings	10⅝d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	20/- to 25/-
,, furnace	17/6
Midlands, foundry	—
,, furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 to 18/7½
,,	28×20 ,,	36/4 to 37/3
,,	20×10 ,,	26/- to 26/6
,,	18¾×14 ,,	18/9 to 19/-
C.W.	20×14 ,,	16/- to 16/6
,,	28×20 ,,	34/- to 35/-
,,	20×10 ,,	23/3 to 23/6
,,	18¾×14 ,,	16/3 to 16/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£6	0	0 to	£7	0	0
Bars-hammered, basis	£16	0	0 to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	0	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£30	0	0 to	£31	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.	
Nov.	8 ..	27	5	0	dec. 6/3
„	9 ..	27	2	6	„ 2/6
„	12 ..	27	6	3	inc. 3/9
„	13 ..	27	5	0	dec. 1/3
„	14 ..	27	10	0	inc. 5/–

Electrolytic Copper

		£	s.	d.	
Nov.	8 ..	30	10	0	No change
„	9 ..	30	0	0	dec. 10/–
„	12 ..	30	0	0	No change
„	13 ..	30	0	0	„ „
„	14 ..	30	15	0	inc. 15/–

Standard Tin (cash)

		£	s.	d.	
Nov.	8 ..	228	7	6	No change
„	9 ..	229	2	6	inc. 15/–
„	12 ..	228	10	0	dec. 12/6
„	13 ..	228	7	6	„ 2/6
„	14 ..	228	5	0	„ 2/6

Tin (English ingots)

		£	s.	d.	
Nov.	8 ..	228	10	0	No change
„	9 ..	229	5	0	inc. 15/–
„	12 ..	228	12	6	dec. 12/6
„	13 ..	228	12	6	No change
„	14 ..	228	10	0	dec. 2/6

Spelter (ordinary)

		£	s.	d.	
Nov.	8 ..	12	3	9	dec. 1/3
„	9 ..	11	17	6	„ 6/3
„	12 ..	11	17	6	No change
„	13 ..	11	18	9	inc. 1/3
„	14 ..	11	17	6	dec. 1/3

Spelter (Electro, 99.9 per cent.)

		£	s.	d.	
Nov.	8 ..	14	16	3	dec. 1/3
„	9 ..	14	11	3	„ 5/–
„	12 ..	14	11	3	No change
„	13 ..	14	12	6	inc. 1/3
„	14 ..	14	12	6	No change

Zinc Sheets (English)

		£	s.	d.	
Nov.	8 ..	23	10	0	No change
„	9 ..	23	10	0	„ „
„	12 ..	23	10	0	„ „
„	13 ..	23	10	0	„ „
„	14 ..	23	10	0	„ „

Lead (English)

		£	s.	d.	
Nov.	8 ..	12	10	0	No change
„	9 ..	12	10	0	„ „
„	12 ..	12	10	0	„ „
„	13 .	12	10	0	„ „
„	14 ..	12	10	0	„ „

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1900	10 0 0	10 10 0	10 10 0	10 10 0	10 15 0	10 15 0	10 5 0	10 5 0	10 5 0	9 10 0	8 15 0	8 15 0	10 1 3
1901	8 0 0	7 10 0	7 5 0	7 0 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 15 0	6 17 11
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10½
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9½
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 0	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9½
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5½
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2½
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	—	—	—

* No quotation available owing to strike.

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Will you help with a donation or annual subscription? Any sum, large or small, will be gratefully received.

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